SCHOOL SCIENCE AND MATHEMATICS

VOL. XV, NO. 7 OCTOBER, 1915 WHOLE NO. 126

TO ALL OF OUR READERS.

Another school year has begun. With it come added responsibilities to all progressive teachers, especially those engaged in science and mathematics instruction in our secondary schools. The best methods for attaining efficient results are not fixed and permanent, but are changing with the progress of the times. Methods which were considered best yesterday are not necessarily the ones which may be most successfully adopted to-day. Those who are doing the best instruction are not altogether satisfied with the results accomplished. They are therefore working out plans, in the light of their experiences, which will enable them to bring about greater results, with less expenditure of time and energy.

As with the highest class of teachers, so this JOURNAL stands for and advances the cause of *pure* science and mathematics teaching in our secondary schools. We are anxious and willing to publish new and original methods of performing old experiments, and are ever ready to print new and interesting developments of how our progressive teachers are securing the best and most efficient results. With this purpose in view we are asking and urging those who have succeeded in bringing out such new schemes and methods of accomplishing more efficient results to submit their manuscript to us for publication. It is proper to say in this connection that SCHOOL SCIENCE and MATHEMATICS reaches a greater number of up-to-date instructors in secondary schools and colleges than any other medium. Its pages are being used constantly as texts in schools and colleges. Nearly all new literature on science and mathematics teaching in these schools contains references to matter in this JOURNAL. No science and mathematics teacher, good or poor, can afford to be without the help which this magazine brings each month. All our readers are therefore asked to help us promote the principles for which we stand, in acting as our agents in the schools and localities where they are at work; we invite criticism and suggestions for improving the JOURNAL.

After being petitioned from many sources, a year ago, we

established a department of Home Economics. Nothing has been published by us on this subject but matter of the very highest grade. However, teachers in this line of work have not responded to the request, as we were given assurance they would, therefore after the next one or two issues this department will be dropped. We may, however, publish four times a year a separate Journal for Home Economics.

RECENT DISCOVERIES CONCERNING X-RAYS.

By Earl R. Glenn,
Froebel School, Gary, Indiana.

This discussion is a brief and necessarily imperfect survey of the recent work in the field of X-radiation. Of especial interest are the notable lectures recently given in America by Professor William Henry Bragg, F. R. S., of the University of Leeds. These addresses, which were given in part at the meeting of the American Physical Society, held at Chicago University on November 27-28, 1914, throw new light upon such textbook statements as "X-rays . . . can neither be reflected, refracted or polarized,"[1] and "Stokes has shown that radiation (nature of Roentgen rays) of such a character would probably not be refracted nor absorbed like ordinary light nor would it show interference effects by which wave lengths could be determined."[2]

New branches of physics have been developed with such rapidity in late years (and let us earnestly hope that scientific genius will escape the blood-stained and mud-bespattered trenches of European battle-fields!) that it is with great difficulty that one gains even a superficial knowledge of the facts of chief importance. It may be the discharge of electricity through gases, wireless telegraphy phenomena, radioactivity, the electron theory of matter, photo-electricity, the important practical applications of well known laws, fundamental discoveries concerning matter at low temperatures, Brownian movement, new developments in sound—now, it is X-rays applied to the atomic structure of crystals, and to the ultimate structure of the atom itself. We sometimes wonder if the atom can finally elude the painstaking genius of present-day physicists.

As Professor Bragg says[3]: "When X-rays were first discovered eighteen years ago it was soon pointed out that they might consist

[1] *A First Course in Physics*, Millikan and Gale (Revised), p. 420.
[2] *College Physics*, Arthur L. Kimball, p. 538.
[3] W. H. Bragg, F. R. S., X-Rays and Crystalline Structure, *Nature*, July 9, 1914, pp. 494-498.

of electro-magnetic disturbances of the ether analogous to those supposed to constitute light. It was true that the new rays seemed to be incapable of reflection, refraction, diffraction and interference, which were familiar optical phenomena. But it was pointed out by Schuster[4] that these defects could be explained as natural consequences of an extremely short wave-length.

As experimental evidence accumulated, a number of results were found which the electro-magnetic theory was unable to explain . . . Experiment seemed to indicate that X-ray energy traveled as a stream of separate entities or quanta, the energy of the quantum differing according to the quality of the X-ray. It looked at one time as if it might be the simplest plan to deny the identity in nature of X-rays and light. Otherwise it seemed that the electro-magnetic hypothesis would be torn to pieces in the effort to hold all the facts together. . . .

The experiment due to Laue (University of Zurich) and his collaborators Friedrich and Knipping (Munich) has already been described in this lecture room (Royal Institution of Great Britain) and is now well known. A fine pencil of X-rays passes through a thin crystal slip and impresses itself upon a pho-

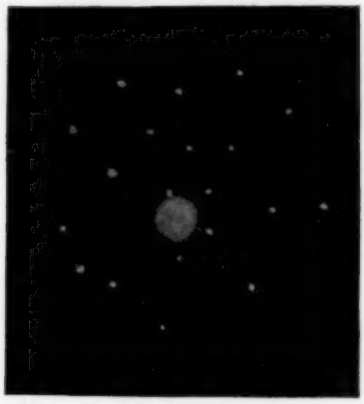


FIG. 1. *Laue Spots, Metallic (sb) Crystal.*
Photo by Owen and Blake.

tographic plate. Round the central spot (see Fig. 1, which is a cut very similar to that shown by Professor Bragg but is a reproduction of a photograph made by E. A. Owen and G. G. Blake as reported in *Nature*, Feb. 19, 1914, p. 687) are found a large number of other spots arranged in a symmetrical fashion,

[4] *Nature*, January 23, 1896.

their arrangement clearly depending on the crystal structure. Laue had anticipated some such effect as a result of diffraction by the atoms of the crystal. . . .

Let us imagine that a succession of waves constituting X-radiation falls upon a plane containing atoms, and that each atom is the cause of a secondary wavelet. In a well known manner, the secondary wavelets link themselves together and form a reflected wave. Just so a sound wave may be reflected by a row of palings, and very short sound waves by the fibres of a sheet of muslin. . . .

Our present phenomenon is exactly the same thing on a minute scale; thousands of times smaller than in the case of light, and many millions of times smaller than in the case of sound. . . .

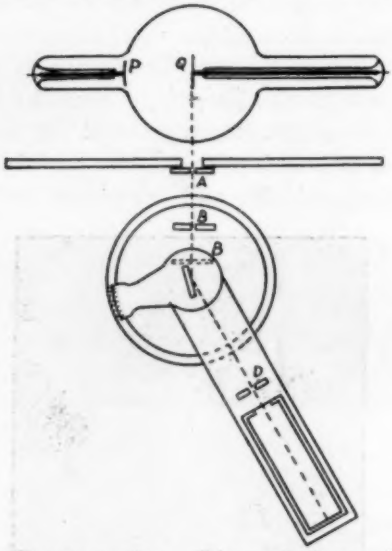


FIG. 2. *X-Ray Spectrometer. Plan of General Arrangements.*

This is 'the reflection method' of explaining the Laue photograph. W. L. Bragg (son of Professor William H. Bragg), showed in the first place that it was legitimate, and in the second that it was able to explain, in the position of all the spots which Laue found upon his photographs. . . .

The simpler conception led at once to a simpler procedure. It led to the construction of the X-ray spectrometer (shown in Fig. 2 and Fig. 3, copied from *Nature*, Oct. 22, 1914, pages 199 and 200), which resembles an ordinary spectrometer in general form, except that the grating or prism is replaced by a crystal, and the telescope by an ionization chamber and an electroscope.

In another paper we read[5]:

"To the collimator correspond a set of narrow slits limiting a pencil of X-rays, which is directed so as to pass through the axis of the instrument. A crystal takes the place of the diffraction grating, and is mounted on a small revolving table. The crystal face or set of planes which is acting as reflector is made to contain the direction of the axis of the instrument, and the crystal is turned round the axis until the face makes the proper angle with the incident pencil. The reflected ray then enters a cylindrical ionisation chamber filled with gas which it ionises. The chamber takes the place of the ordinary telescope, and the measurement of the ionisation current by an electroscope corresponds to observation by eye or by the photographic plate. . . .

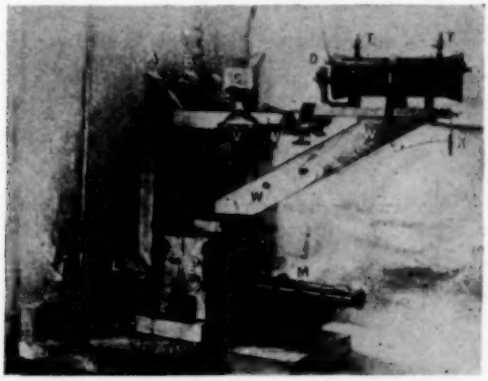


FIG. 3. *Photograph of X-Ray Spectrometer.*

In the drawing of Fig. 2, which shows the arrangement of the apparatus in plan, Q is the antikathode of the X-ray bulb. The construction of the bulb is a little unusual in that the antikathode is placed perpendicularly to the kathode ray stream; the bulb can therefore be conveniently arranged so that the X-rays leave the antikathode at a grazing angle. . . .

The X-ray bulb is enclosed in a wooden box heavily coated with lead. The object is to protect not merely the observer but also the sensitive apparatus. The slit through which the rays pass is only a few millimeters long, and very narrow, sometimes not more than a tenth of a millimeter wide.

The side of the box is shown on the left of the photograph of Fig. 3. Adjustable slits are placed at A, where the rays leave the box, and again at B, the second slit being also capable of

[5]The X-Ray Spectrometer, *Nature*, Oct. 22, 1914, pp. 199-201.

movement, which brings it close up to the crystal, as at B′. The crystal is shown at C, and a third slit, D, is placed just in front of the ionisation chamber.

The ionisation chamber is marked I in Fig. 3. It is a cylindrical brass chamber 15 cm. long, and is filled with some heavy gas, so that the ionisation current may be as large as possible. The chamber I is insulated and maintained at a high potential, which drives any ionisation on to an internal electrode. The latter is connected by a fine wire which passes down inside the metal shield WW to the gold leaf electroscope within the shield E. The connection with the electroscope terminal is made at a point lying on the axis of the spectroscope, so that the ionisation chamber I, the casing W, and the connecting wire may all revolve together about the spectrometer axis without straining the connection. . . . . .

The gold leaf is illuminated by reflection from a mirror L, and viewed through a miscroscope M. A strong X-ray reflection will cause the leaf to move 20 to 30 scale divisions in a second. The angular positions of the crystal and the ionisation chamber are read from verniers at V and V′. Fig. 4 is reproduced from the advertising columns of *Nature*, November 19, 1914.

"Observations can easily be made to half a minute of arc, and much finer work could certainly be done, if it were required."

Concerning the experimental results and their importance we quote at length from an excellent review[6] of Professor Bragg's lectures at Brown University:

(*a*) "It is now clear that X-rays are exactly the same thing as light rays, except that the wave length is roughly ten thousand times smaller.

(*b*) "The undulatory theory of light has been extraordinarily successful in correlating experimental facts. Towards the end of the last century it seemed as if it had conquered all the great problems of physical optics. More recently it has shown signs of inefficiency. For example, it seems unable to account for the so-called photo-electric phenomena. Incapacity has been still more obvious in connection with the properties of X-rays.

(*c*) "The wave lengths of X-rays can now be measured exactly, and other characteristics of X-rays can be expressed in terms of these. Remarkable relations have already been found to exist, for instance, between the wave lengths of the X-rays emitted by

[6]Crystals and X-Rays, *Popular Science Monthly*, December, 1914, pp. 616-617.

various atoms under proper stimulus, and the position of these atoms in the table of Mendelejeff.

(*d*) "The new experiments provide a means of investigating the structure of crystals. We are able to determine the arrangement of the atoms in a crystal and to measure the distance from atom to atom.

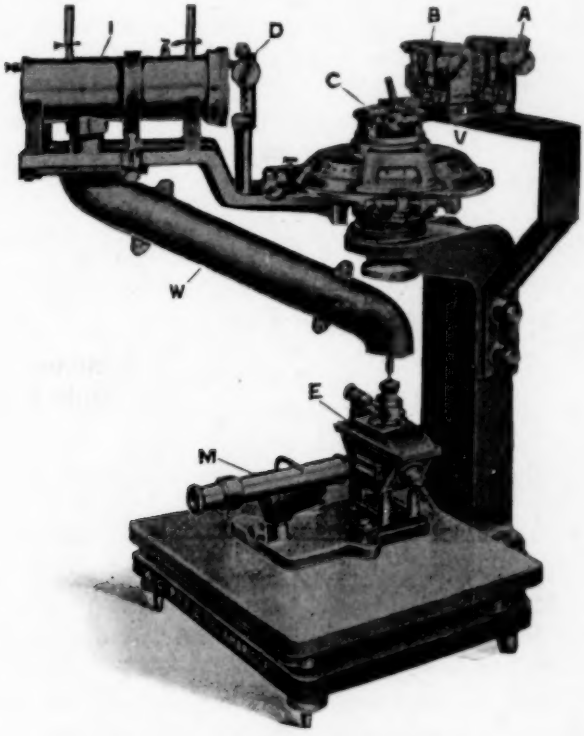


FIG. 4. *X-Ray Spectrometer.*

(*e*) "The motions of the atoms about their average positions is made manifest. Little experimental work has yet been done in this direction, but it does not seem unlikely that we shall presently measure the extent of the atomic movements which contribute to the heat content of a body."

(*f*) *"Let it be admitted at once that the quantum theory and the orthodox theory appear to stand in irreconcilable opposition. Each by itself correlates great series of facts; but they do not correlate the same series. In some way or other the greater theory must be found of which each is a partial expression."*[8]

[8] *Nature*, November 26, 1914, pp. 349-354.

From the reports of the British Association in Australia is gathered a review of the lectures of Sir Ernest Rutherford[9]:

(*a*) "The independent existence of the chemical atom is no longer merely an hypothesis introduced to explain the laws of chemical combination; we are able to detect and count the individual atoms.

(*b*) "The atomic character of negative electricity is well established; we always find the negative electron, however produced, carrying a definite charge.

(*c*) "More recent discoveries point to a concentrated positive nucleus. We have now two powerful methods which aid us in determining the inner structure of the atom—the scattering of high speed particles in transit through matter, and the vibrations of the interior parts of the atom.

(*d*) "In C. T. R. Wilson's photographs of the tracks of the alpha particles through a gas, we notice many sudden bends in the paths;——it is found necessary to believe that there is a concentrated nucleus atom, in which the main part of the mass resides; outside this there are a number of electrons. Another fact that appears from the scattering experiments is that the number of electrons (outside the nucleus) is about half the atomic weight. There is now fairly good evidence that, if the elements are numbered serially in order of atomic weight, the numbers will actually express the charge on the nucleus.

(*e*) "Each substance has two strong lines in the X-ray spectrum.——It is deduced from these considerations that there is something more fundamental than atomic weight, namely, the charge on the nucleus.

(*f*) "It is quite clear that some new conception is required to explain how the atoms, having the structure we have supposed, can hold together."

In conclusion,—what shall we teachers of physics say to students when this field of science comes up for consideration? Shall we depend upon text-book revision, every five years, for up-to-date scientific information, or shall we carefully read two or three standard journals and regard the statements therein as being as valid as those found in texts?

Or, shall we emphasize "practical application" to the almost complete exclusion of descriptions of the momentous struggles now in progress in the field of science? The chapter of scientific history that is now being written concerns the ultimate structure

[9] William H. Bragg, X-Ray and Crystalline Structure, *Science*, Dec. 4, 1914, p. 796.

of the atom,—it may be comparable in interest and possibly superior in significance to any that man has yet written. What order of civilization would follow the discovery of a method for liberating the enormous stores of energy within the atom? And what shall civilization do if such a discovery is *not* made?

Practical—yes, practical we shall be in order to live, but we must not be so *impractical* as to fail to appreciate, and to teach appreciation of present day science and scientists. When one sees the X-ray photographs of bullets and other missiles in the various parts of bodies of the French soldiers,[10] one can conclude that, from the standpoint of human benevolence and relief, the theory and facts of X-radiation are comparable in practical importance to any branch of modern physics.

[10] E. Jacques, La Recherche des Projectiles Par La Radiographie, L'Illustration, No. 3743, 72 *me* Année, 28 November, 1914.

SELECTED BIBLIOGRAPHY.

1. E. E. Fournier d' Albe D. Sc., The Radiation Problem, Sci. Amer. Sup., April 18, 1914, p. 243.

2. Dr. Wheeler P. Davey, Our Present Physical Knowledge of X-Rays, Sci. Amer. Sup., March 28, 1914, p. 198. (Very complete discussion of the properties of X-rays.)

3. Herbert T. Wade, The New Coolidge Roentgen Ray Tube, Sci. Amer., Feb. 21, 1914, p. 157.

4. Dr. Wheeler P. Davey, Some Interesting Applications of the Coolidge X-Ray Tube, General Electric Review, Aug., 1914, p. 792. (Showing twenty-five remarkable X-ray photographs.)

5. Dr. Saul Dushman, Recent Views on Matter and Energy, General Electric Review, (*a*) Part I, July, 1914, p. 694; (*b*) Part II, September, 1914, p. 901; (*c*) Part III, October, 1914, p. 952; (*d*) Part IV, December, 1914, p. 1197.

6. The X-Ray Spectrometer, Nature, Oct. 22, 1914, p. 199.

7. W. H. Bragg, X-Rays and Crystalline Structure, Nature, July 9, 1914, p. 494; also Science, Friday, Dec. 4, 1914, p. 795, and Sci. Amer. Sup., Jan. 2, 1915, p. 5.

8. Dr. Wheeler P. Davey, An X-Ray Inspection of a Steel Casting, General Electric Review, January, 1915, p. 25.

LARGE CHROMIC IRON ORE DEPOSITS IN CALIFORNIA.

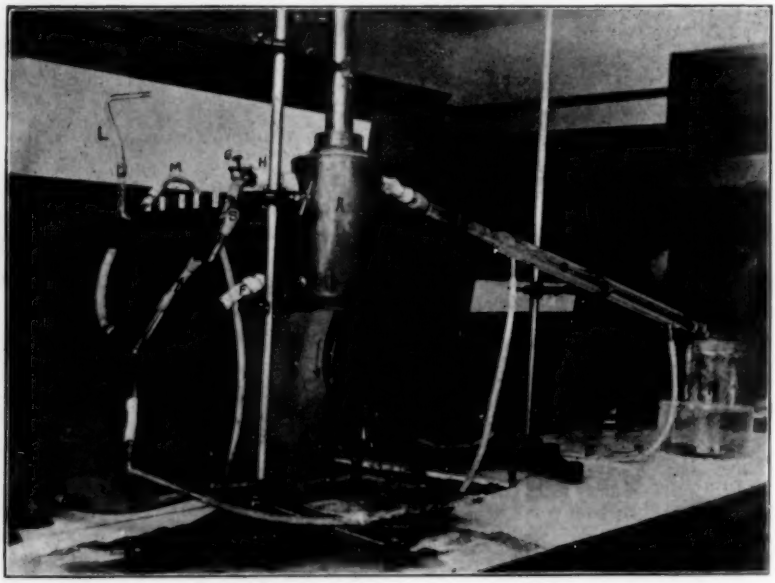
Deposits of chromic iron ore occur in Maryland and the adjacent portion of Pennsylvania, in North Carolina, and in Wyoming, but the only deposits operated in the United States within recent years are in California. Numerous deposits have been reported in 32 counties of that state according to the United States Geological Survey, and many of them could be worked if the demand for the ore and its value warranted exploitation. The available deposits, with much in reserve, largely exceed the local demand for refractory material in a field extending as far east as the Rocky Mountains.

AN ATTACHMENT FOR AUTOMATIC DISTILLATION.

By Roy W. Kelly,
High School, Pacific Grove, Cal.

Nearly every laboratory finds a number of uses for distilled water but it is not always possible for an expensive still to be installed. Teachers who have had the experience of allowing copper boilers to burn out or glass flasks to be broken by letting them boil dry in distilling small amounts of water will appreciate the convenience and economy of a simple automatic still.

The apparatus described is used as an attachment for "Apparatus A," a form of copper boiler very widely used in physics laboratories. The only other essential is some form of condenser.



Referring to the photograph, water enters from the hydrant and passes through the tube B in the direction indicated by the arrows. After flowing through the jacket of the Liebig condenser, it goes through tube D to the Y at E. Connection is made at this point to the boiler through the tubes H and K. The overflow passes out through M to the sink. L is open to the air. When the flow of water through the jacket of the condenser is properly adjusted, it will flow in a steady stream filling the tubes to the Y at U. From here the air entering from L causes it to flow in a series of bubbles forming an intermittent stream. The tube M at its highest point will need to be about

one inch above the level of the Y at S in order to counteract the pressure of the steam from H. In the photograph a stopcock is shown at G in order to leave only a small opening to H. Nearly sealing the tube will answer equally well. It must not be completely closed as this will stop the operation of the still. When steam has commenced to come from the boiler, slight adjustments of the height of M, or of the flame of the burner N, or of the flow of water will so regulate the amount of water in the Y at S as to keep it about half full of water.

Fluctuations will occur as the pressure of the gas or water changes, but the boiler cannot possibly go dry even if these changes are great if M is properly elevated above S. The whole operation of distillation is entirely automatic after the first adjustments are made and these are not at all difficult of accomplishment.

In addition to being automatic, a saving in gas is made by using the water from the jacket of the condenser to fill the boiler. It will be found desirable to cover the rubber connections with asbestos and a tin shield placed around the burner will keep in a considerable amount of heat. A yield of about a liter per hour should be secured from a burner turned at about half its maximum height.

While the attachments can be made up as illustrated, a simpler form could be made in two pieces by a glass blower which would be more convenient and work somewhat more satisfactorily.

MILL TAILINGS FOR ROAD METAL.

In Missouri a considerable amount of road material is obtained from the tailings of the concentrating mills at the zinc mines. This material, which is put on the market as "chats," consists of small angular fragments of chert and limestone. The zinc companies are very glad to get rid of this waste material, which is loaded on the cars by the railroads of the district at a cost of about 6 or 8 cents a ton. It makes more than ordinarily good roads and is widely distributed all through the Middle West. It sells in most places at prices ranging from 50 cents to $1 a ton, but in the neighborhood of the mines it can be had for about 15 cents a ton. It is used for railroad ballast as well as road making. The annual output, according to the United States Geological Survey, amounts to about 1,300,000 tons.

In Tennessee and Alabama a quantity of chert is used for road metal, and in many States crushed slag from blast furnaces also furnishes a valuable road material. In Alabama, one of the large iron-producing States, over 2,000,000 short tons of furnace slag, the average value of which was about 25 cents a ton, was crushed and put on the roads last year. Crushed slag is also used as railroad ballast and for concrete and roofing material.

HOW I MAKE FIELD WORK IN PHYSIOGRAPHY CONCRETE.

By Eunice R. Blackburn,

Hittle Township High School, Armington, Ill.

My subject reads, "How I Make Field Work in Physiography Concrete," so I shall, with your permission and as the title assigned me demands, be personal and speak only of those things which I have tried and experienced.

For anything to be successful we must formulate specific aims. Among the many good reasons for field work in Physiography I will take up three. First, field work makes the work interesting; second, it makes the text book work concrete and, third, it helps the pupil to interpret the printed page.

Every boy or girl between the ages of two and eighty loves to be out of doors, when the weather is pleasant, so any subject which allows him this pleasure is sure to be a favorite, especially when he can actually see gullies widen, alluvial fans deposited and waterfalls worn down. He then sees that nature is at work on the school grounds as well as on the mountains in Europe. Then, field work helps the pupils to notice things of nature and to realize that it is not necessary to go to Switzerland to see beautiful things. A waterfall may be only a few inches high and yet show all the features (except grandeur) of the Niagara. Not long ago two of my pupils went to Peoria. In telling me of the trip the first thing one girl said was, "Oh, we had the most fun, we tried to see who could see the most physiographic features from the car windows."

The fact that the human mind must work from the known to the unknown is well shown in the fact that the ancients in order to represent an idea of a god either made the image of some animal or used some combination of animals. Thus in the study of Physiography a child must have some images from which to build, and it is much easier to make concrete comparisons and draw conclusions in the field than in the class room.

How is the average high school boy or girl having lived all his life on the prairies of Illinois to actually picture the work of running water when the canyons mentioned in the text are in Colorado, the oxbow lakes on the lower Mississippi river, the alluvial terraces in China and waterfalls in Wyoming, unless he actually sees these things in Mr. Hickey's pasture, or along the road, on a small scale to be sure but just as perfect as those men-

tioned in the text. They may lack the beautiful surroundings, color and variety but they are actual growing, moving things while the text book picture is not. And the pupil through the known cascade and description and pictures is able to actually picture in his own mind the example given in the text.

Not long ago a graduate of one of our splendid colleges in this state said to me, "I know I am ignorant but how does an alluvial fan look?" Now she had had sufficient text book work yet was unable to picture the actual thing. It was after a rain and I showed her a small one and she said, "Well, why did not some one show me that before?"

If high school boys and girls were able to interpret a printed page many of our trials would be over. How many times a day do we have to stop and read a seemingly simple statement over with a pupil? Many times just the reading with the proper emphasis and no word of explanation is sufficient. How many times do even grown people fail to get the meaning from a printed page? How many women of your acquaintance prefer to be shown how to do a pattern of crotcheting or tatting rather than follow printed directions? If we are to "make ourselves useless" to our pupils or, in other words, to fit them best for life outside the school, they must be able to take a printed page and work things out for themselves. After working out some point in the field that was particularly hard or impossible to image from the text book alone, as for instance, the fact that rivers grow in length at their sources, or, as some text books say, grow backwards; a rereading of the text will help the pupil to form an image from mere words. Thus he forms the habit of thinking back into his experience and of building the image of the unknown from the known. Many boys and girls find description of scenery tiresome and always skip to the conversation because the description is merely a lot of words. They find nothing in their experience which is in any way related to this. I find that at the end of the semester the pupils can more readily form mental pictures from word descriptions.

I have never heard any objections to field work from parents or board, and but one of my pupils has complained. She objected to long walks and was granted the permission to stay at home when the trip was to be a long one, and hand in a paper discussing the things we went to see. I have heard that a few superintendents and principles object to field trips because they fear the discipline will not be as it should. I have never taken

a class of more than twenty-five and have had but two problems to solve. The first was of a boy who wished to show off and attract the attention of the other pupils. I simply left him at the school building the next time the class went on a field trip with the directions to write an essay on the subject which we expected to study. I have never been troubled since. The second problem I had was with a girl who "adored" field trips and begged loudly for many, yet was always too tired and exhausted to be on time for school the next day. When this had happened twice, the day I wished to go I announced in the morning of the field trip and gave usual instructions for the wearing of rubbers. At noon she was all smiles talking about the trip. I gave her a long list of references and a subject for a written report and told her that I felt very sorry she was unable to accompany us, because we had noticed she was in too poor health to take so much exercise. After she had shed sufficient tears and promised to be on time the next day, and assured us of her excellent health she was permitted to attend, on trial, as we had planned she should. We had no further trouble with her.

I have found that usually a teacher has the kind of order she permits. And the class soon find it out. On starting out I ask the class to stay together and no one is ever allowed to get more than twenty feet away from me. We never go until after the first week of school and by that time I have found out with whom to walk and whom to watch. We talk and have a quiet, good time until we come to the place where we are to stop and examine some particular thing. Then everything is as in the class room.

The things which can be seen to an advantage vary in different communities; yet I think that the work of ground water, running water, the effect of ice in ponds and streams, deposition of sediment by melting snow, effect of the atmosphere and the effect of plants and animals on the topography can be observed in every community.

The field work that we do for the study of ground water is in noticing landslides, slumps and creeps which are found most easily along the cuts and fills of the railroad track. We also notice the mineral matter in well water.

The work of running water offers the greatest variety of examples. We note the growth of valleys, gullies, canyons, divides, water falls, rapids, young and old streams, meandering streams, oxbow lakes, flood plains, valley flats, terraced valleys, depositions

in the bed of stream, sand bars, alluvial fans and cones, and deltas.

The work of running water can be more easily studied on a small scale than on a large one. It was my privilege to teach for two years on the banks of the Mississippi. Yet when we studied the work of running water it was necessary to go to the road, or hillside, as there we could see the work being actually carried on fast enough for us to watch it. If the road slopes, slightly it affords an excellent place to watch the work of running water, as does any other place partly or wholly free from vegetation and not too hard, especially freshly turned soil, and the banks along the railroad. Small gullies in a pasture afford ample illustration of the growth and deposition of rivers, especially if they can be visited before and after a rain. Where I am now teaching our best place is about a mile from the school house. As we have one hour and a half for our trips, we take the trip the last two periods of the day if possible so we do not have to be back at any certain time. We can easily go and come in an hour, notice the features on the way, and have half an hour at the "Grand Canyons of Mr. Hickey's Pasture," as we have named them. Excellent examples of all the important features in the work of running water are found there, although the deepest canyon is not more than three feet deep or four feet wide at the top, and the largest alluvial plain is not more than fifty feet across. However, it is easy to find the examples for every little stream. If only one in the wagon track, it shows the important characteristics of the large streams although the boys and girls, unless some one points them out, will fail to see them.

The effect of plants on Physiographic features may be seen by a comparison of a pasture and freshly plowed field after a rain. We note changes made in banks of streams by animals and make a list of animals in our county which change the surface of the land.

When a large drift of snow melts, a pile of sediment is left which illustrates in a very satisfactory way the building of moraines. In many communities are the moraines of the ancient glaciers. However, after noticing the sedimentary deposit of the drift it is much easier to imagine the way a glacier deposits.

The work of ice in streams and ponds can be seen some seasons, but in others the ice is not thick enough to make a noticeable effect on the banks. In studying the work of the atmosphere we note the crumbling of stones in buildings, a boulder or monu-

ments in the cemetery, noting the difference between the polished and rough as to amount of crumbling.

The number of field trips taken depends on the class and the material found. I like to take a class on a trip the day the work was assigned. For example, if the text book lesson was on canyons, I like to go that day, before having recited on the subject. But this is not always possible since the weather and the distance from the desired canyons must be taken into consideration. So sometimes we wait and take several points at once and also look forward to others soon to be handled. This saves time and also illustrates the fact that usually more than one force of nature is at work, simultaneously, in one particular place. However, care must be taken not to take up too many points at one time, otherwise the pupils do not get distinct images. It is much better to select a few types and find many examples of each type.

I find that the time spent in field work is really time saved; for a pupil can get in five minutes of actual observation (and that for all time) what will take him half an hour to gather from the textbook—and then he stumbles over and half disbelieves it, as in the case previously mentioned; that gullies grow backward. A few minutes will show this to be the only way possible. The average boy, with only a book knowledge, will find a dozen questions to ask and doubts actualities.

There is no advanced textbook assignment made for the day after the trip, but the pupils are required to write a report of the trip. A comparison of these compositions with some of the required description in English reminds one of the old saying,

"For what avails a sea of ink
To him who has no thoughts to think.'

We must always keep in mind that the we are teaching boys and girls, and not subjects, and that what will best develop them must be brought out. And in teaching them to observe nature and to draw conclusions we are opening to them a door to the study of things worth while.

EARTHQUAKE CONSTRUCTION.

In those districts of Italy where seismic disturbances are especially liable to occur, considerable advances have been made in what is known as earthquake construction, that is, the erection of buildings under strict supervision with respect to their ability to resist earthquake shocks. Professor Omori, a Japanese authority, has estimated that 99.8 per cent of the deaths in the great Messina earthquake of 1908 could have been prevented if the buildings had been properly constructed.

A SIMPLE GAS METER FOR USE WITH THE JUNKER CALORIMETER AND FOR TESTING SERVICE METERS.[1]

By C. W. Waggoner and J. W. Hake,
West Virginia University.

Living in a state where a great quantity of natural gas is produced and where gas meters of all kinds are in common use, the writers have tried to develop several simple laboratory experiments which would illustrate some of the laws and properties of fuel gas. The result of this study has led to two experiments: 1, The test of the accuracy of an ordinary house or service meter, and 2, The determination of the caloric value of one cubic foot of gas by the use of a simple Junker calorimeter.

In both of these experiments it was necessary to have a simple, yet reasonably accurate, gas meter or gasometer that would provide for a steady flow of gas, easy change in pressure and whose calibration could be made or checked by the student without resorting to expensive standards. Last, but not least, the standard meter should be inexpensive; so that at least four complete sets could be provided for each laboratory period in order that each student in a rather large freshman class could have an opportunity to perform this experiment if he chose to select this one from the group of experiments somewhat similar to this one.

When this work was first undertaken a Thorp Gauge, calibrated for coal gas, was tried, but it was found to be absolutely unreliable as the results in the following table for natural gas and air will show. We have two of these gauges, one marked for coal gas, the other presumably for natural gas. The results in the table are for No. 5727 which was calibrated for coal gas. The other gauge, No. 2976, showed a tendency to stick fast to the glass tube at most any reading and would not repeat the reading after it had been jarred loose. Another objection to this form of meter is that the principle upon which it operates is more difficult for the average student to understand than the meter herein described, and the calibration of this form of meter must be made with some standard meter.

Table No. 1. Showing the flow of gas and air through a Thorp Gauge and the Meter Prover.

---

[1] After this article was prepared for publication the writers received from Wm. Gaertner & Co. a trade publication describing a very similar gas meter that had been designed by Prof. Bishop, of Chicago University.

Rate of Flow per hour.	Meter Prover.	Thorp Gauge No. 5727.
	Air.	
6 cu. ft. hr.	2 cu. ft.	3 cu. ft.
8 cu. ft. hr.	2 cu. ft.	2.96 cu. ft.
9.9 cu. ft. hr.	2 cu. ft.	2.84 cu. ft.
	Natural Gas.	
6 cu. ft. hr.	2 cu. ft.	2.51 cu. ft.
8 cu. ft. hr.	2 cu. ft.	2.31 cu. ft.
10 cu. ft. hr.	2 cu. ft.	2.24 cu. ft.

It is clear from the above table that these gauges are not satisfactory for a wide range of gas flow.

Accurate standard rotary meters listed in the various catalogues were held to be undesirable in these experiments, first because of their cost and second, because it was decided to show how service or house meters are tested in actual practice. In the first determinations of the heating value of one cubic foot of gas by the use of a simple Junker calorimeter a good grade of service meter was used, but it was found practically impossible to duplicate the data in successive tests on account of the variation in the gas pressure in the laboratory mains. During the busy hours of the day this variation was found to be as much as 18 to 60 cms. of water. If the gas was throttled to give the proper height of flame in the Junker then any slight drop in the line pressure would cause the flame to go out. On the other hand, an increase in the pressure caused too much gas to pass through the burner and a low value for the calorific value of gas is a result of the incomplete combustion of the gas in the burner. However this might be remedied by the use of a large tank in which to store the gas, but the meter described in this paper furnishes such a tank and at the same time serves as a meter. Another objection to the use of an ordinary service meter is that most meters will not accurately record the gas passing unless the amount is in excess of one cubic foot. The diâls of most meters of this kind have a hand which reads a maximum of two cubic feet and the dial is graduated to one-fifth of a cubic foot. It seemed desirable also in the Junker test to reduce the quantity of the gas passing through the burner to standard conditions, i. e., atmospheric pressure and 0° C. temperature and the data for this transformation was more easily obtained with the apparatus described than when service meters were used.

This type of meter was suggested to us by the Meter Provers used in testing service meters by the various supply companies under the requirements and directions of the Public Service Commission. A Standard Meter Prover of the type described is manufactured by the Pittsburgh Meter Co., East Pittsburgh, Pa.

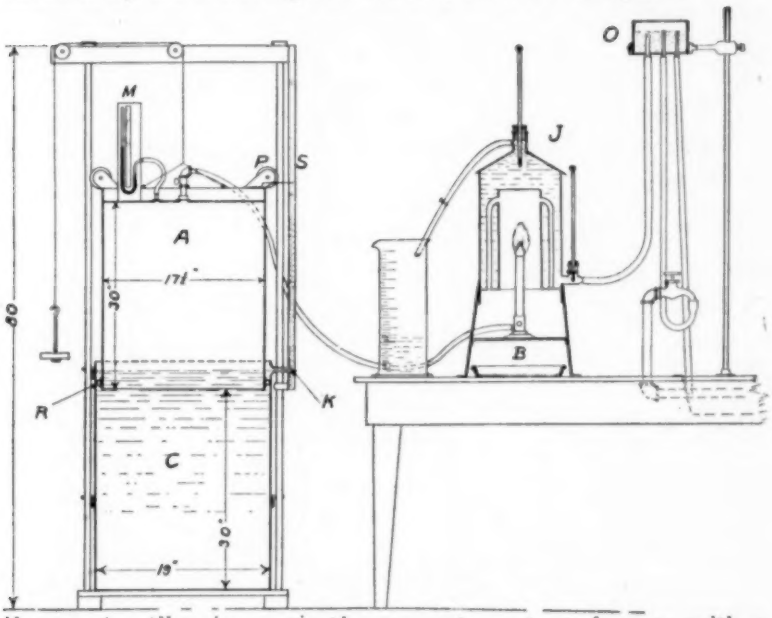


FIGURE 1. *Showing a simple gas meter set up for use with a Junker Calorimeter for the determination of the calorific value of one cubic foot of fuel gas.*

In Figure 1, A and C are two large galvanized iron tanks which were made by a local tinner for $4.00 complete. The mechanism for sliding A into C was constructed in our shop and consists of two hot-house pulleys P, three small rollers R spaced at equal distances around the bottom of A and a pulley system with a counter-weight. M is a water manometer for reading the pressure in the tank. A was calibrated by direct measurement of its volume and the scale S graduated to read in .02 cu. ft. per division. The capacity of these meters with the dimensions shown on the diagram is about three cubic feet.

Test of a Service Gas Meter.

The meter under test is connected to the gas cock on the top of A. A is pulled up to the top of the scale S, water at room temperature is poured into C until it overflows at K. A is dropped

down and the air thus entraped is forced through the meter under test. The pressure of the gas is adjusted, either by placing weights on the top of the tank A or by removing weights from the counter-weight until the manometer M shows the desired pressure. As the tank A sinks into C the displaced water flows out at K and thus the water level in C is maintained constant. By reading the barometric pressure and the temperature of the water in C the gas passing into the meter may be reduced to standard conditions.

Table 2. Showing some tests on two service meters at various pressures.

Pressure in Cm. of Water	Meter Under Test.	Meter Prover.	% Error.
	Meter No. 2.		
9 cms.	2 cu. ft.	2.26	+11.5
11 cms.	2 cu. ft.	2.20	+ 9.1
13 cms.	2 cu. ft.	2.12	+ 5.6
	Meter No. 3.		
6 cms.	2 cu. ft.	1.89	— 5.8
8 cms.	2 cu. ft.	1.90	— 5.3
10 cms.	2 cu. ft.	1.90	— 5.3
12 cms.	2 cu. ft.	1.89	— 5.8

In Table 2 are given some results on two service meters that were taken from a student's laboratory report. In commercial testing it is customary to pass at least ten cubic feet of air through the meter under test. The Public Service Commission of West Virginia require an accuracy of 2% in all meters put into service.

The Determination of the Calorific Value of Gas With a Junker Calorimeter.

The Junker Calorimeter shown in the figure is supplied by the Central Scientific Co. and for student use is quite satisfactory. For many years this experiment has been given by the engineering departments to their technical students, but there seems to be no good reason why students in general physics should not profit by such a study and the writers have been very much gratified by the results obtained from a class of seventy freshmen in which engineering, agriculture, arts and sciences, and the medical colleges were represented. The Junker calorimeter and its operation will be found described in a number of standard laboratory manuals: Carpenter's *Experimental Engineering*, Ferry's *Practical Physics* and Duff and Ewell's *Physical Measurements*.

The operation of the meter is very similar to that in the test of a service meter. A is allowed to sink into C to displace all the air, water is filled in until it overflows at K, then A is filled with natural gas by connecting the gas cock on its top to the gas mains and displacing the water in A by the gas for test. The gas is kept in the tank until it has reached the temperature of the room as observed by taking the temperature of the water in C.

Table 3. Showing the results of one student's determinations of the calorific value of natural gas.

Amount of gas consumed, one cubic foot.

Time for one run, one and one-half hours.

Average temperature of inflowing water, 6.1°, max. variation, .1° C.

Average temperature of outflowing water, 22.85° C., max. variation, .35°.

Total quantity of water flowing through, 17060 c. c.

Water condensed from the burner, 39 grams.

Temperature of the room, 20°C.

Barometer, 73.92 cms.

Pressure in the tank above atmospheric pressure, 3.5 cms. of water.

Calorific Value, 1139 B. T. U. per cubic foot at standard conditions.

In Table 3 is given one determination of the calorific value of natural gas taken from a student's report. It will be seen that the apparatus described is capable of maintaining a gas flow which is very steady, such that the outflowing water does not change in temperature more than .35° C. from the average temperature during the time of the run.

The values for the calorific value of natural gas vary from 1136 to 1147 B. T. U. per cubic foot as given by the State Geological Survey whose determinations were made with a high degree of precision and of course by the use of a much more accurate Junker than was used in the student tests. Artificial or manufactured gas has a calorific value of about 600 B. T. U. per cubic foot and from the above values it will be seen that the natural product has almost twice that value.

The meter described has been found very useful in supplying gas for the sensitive flame and the manometric flame apparatus in sound experiments where the successful operation of these depends upon a steady flow of gas. It is hardly necessary to mention its use in measuring the gas consumed in small stoves,

gas flat-irons, gas lights where the amount is very small and could not be measured with accuracy by a service meter registering to one-fifth of a cubic foot.

Filled with air the meter produces a very steady stream of air for blowing organ pipes, etc., in a laboratory not otherwise provided with an air pressure system.

The apparatus may be used as an acetylene generator by the addition of a wire basket fastened to the top of A, in which to place the calcium carbide.

It may be used as an aspirator for experiments in hygrometry by merely reversing the operation of testing a service meter and arranging to pull air into the tank A by placing a sufficient mass on the counter-weight.

SCIENCE AND MATHEMATICS SOCETIES.

This Journal will gladly publish accounts of the meetings of Science and Mathematics Societies, and will also print announcements of their meetings, if the officiary of the various societies will inform us in time of the place and date. The publicity that this Journal will be able to give to the meetings will undoubtedly be productive of a larger attendance than these gatherings would otherwise have, and at the same time will keep instructors in touch with that which is going on not only in their own locality, but all over the country.

SCHOOL PARKS.

There are a few progressive school men, especially those in the biological sciences, who are beginning to realize that School Boards in all large cities should be the owners of considerable tracts of territory near these particular cities—these tracts to be used for the purpose of biological and nature study work in all phases that it is possible to carry on such work. This could be done by cultivating the soil and making a close and careful study of the habitat of the various wild flowers and plants indigenous to the locality, as well as by the investigation and study of the animal life, not only on the ground and in the bushes and trees, but in the ponds as well. In the long run this would be economy and would be productive of the highest proficiency in nature study work. At present in many of our larger cities, the work in the subjects referred to must be carried on in ways that are not at all advantageous to a correct knowledge of the subject. The material that is used is in many instances unsuitable. Then, too, the pupil is unable to couple the material studied with its proper environment. It might be said in this connection that it would be a wise policy for Boards to erect buildings in these proposed parks, in which instruction could be given in all phases of the work which would center in this particular territory. It would be very easy to take pupils to such places, and it would be a good scheme to have provision made for keeping the pupils in the park for several days at a time, in order that they might make a complete study of the life in the park. Biology and nature study instructors should use all of their influence to bring about some such condition in every large city.

IMPULSE ELECTROSCOPE.

(For the study of radio-activity, etc.)

By C. C. Kiplinger,
Dept. of Chemistry, Iowa State College, Ames, Ia.

Some four years ago, while in high school work in Illinois, the writer devised an electroscope for student use which proved very satisfactory in practice. Recently, somewhat the same principle has been utilized by several other workers. In brief, the instrument herewith described is simply a modified Coulomb's torsion balance.

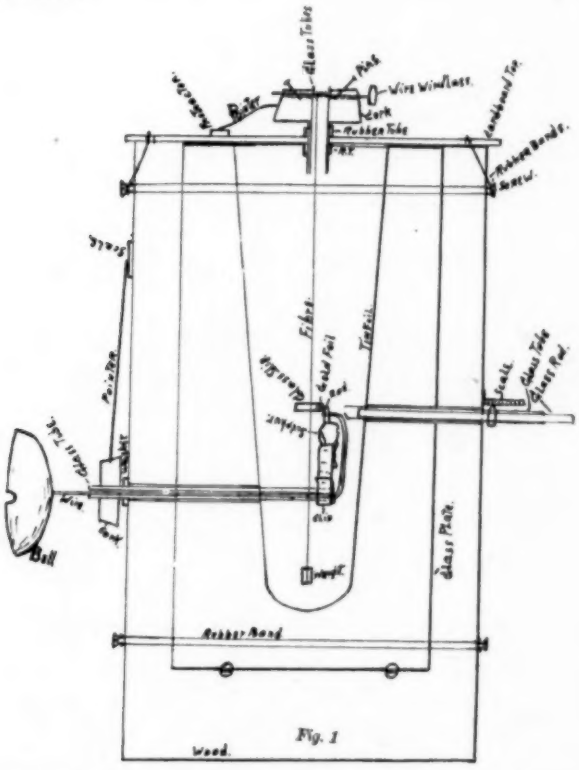


Fig. 1

The effect of a weak current of electricity on a galvanometer may be magnified if the current be made intermittent, with an interval between pulses equal to the period of the galvanometer needle's swing. Such a series of small forces acting periodically may, under favorable circumstances, produce greatly augmented results. With this principle in mind, the following described electroscope was constructed, which, in spite of its crudeness, has proved very sensitive.

The body of the instrument comprises a piece of 1½ inch board cut as shown in figure 1. The inside faces of the prongs are covered with tin-foil. Two 3/8 inch holes are bored through the prongs in the positions shown. Two strips of plate glass, old negative glass is good, form the faces of the instrument case. These are held in place by strong rubber bands and screws. Three large curtain rod hooks screwed into the body form a base and also serve as a substitute for leveling screws. A piece of heavy cardboard, figure 5, forms a cover for the top. This is held in position by rubber bands snapped over the notches and side screws.

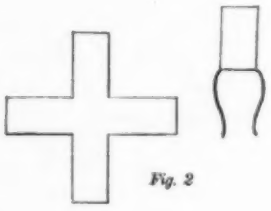


Fig. 2

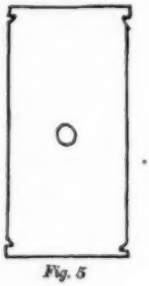


Fig. 5

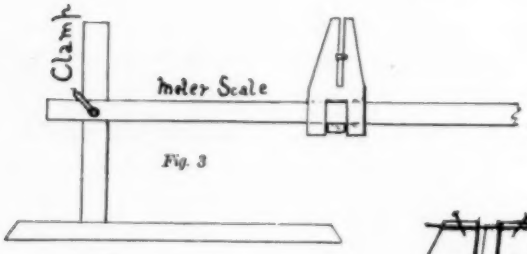


Fig. 3

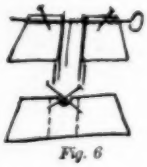


Fig. 6

Fig. 4

A narrow strip cut from a thin microscope cover glass is suspended from a small windlass of cork and wire by a hair, silk fibre, or quartz filament. The details of the windlass are shown in figures 1 and 6. A piece of wire inserted in the cork for a pointer and a protractor attached to the cover with strips of gummed paper, permit measurements to be made of the degree

of torsion to which the fibre is subjected. To the lower end of the fibre is fastened a small weight which tends to keep it vertical when a force acts on the glass slip. Both slip and weight are attached to the filament with a bit of shellac. A tiny piece of gold or aluminum leaf is fastened on one end of the glass needle.

A piece of thick walled glass tubing, capillary, of such diameter that it will turn with slight friction in the lower of the two holes in the prongs has a six inch length of No. 18 copper wire passing through it. To one end of the latter has been soldered a bell from a discarded alarm clock. The end of the wire extending into the instrument is bent as illustrated in figure 1. A double clip made from sheet brass, or a double photo clip, is snapped over the interior end of the glass tube (figure 1). It should grasp the tube firmly. The other end of the clip holds a piece of sulphur or other insulating material. This supports a small rod of one-eighth inch brass wire attached to it by first heating the rod over a lighted match and then allowing the rod to melt its way into the material. The copper wire should be bent until it touches the rod when the bell is turned through a certain angle. Thus, the rod may be charged and then isolated on the insulator. A notch on the rim of the bell allows it to be turned by means of an insulated rod.

Furthermore, the rod conductor may be larger or smaller than the one suggested, or may differ in shape, so that the electrostatic capacity of the instrument may be varied at will. A wire pointer attached to the tube by means of a cork, and a scale, serve to designate roughly the position of the conductor. Both slip and rod are adjusted so that a charge on the latter causes a twisting stress on the former and its fibre suspension. The end of a 3/8 inch glass tube is partly closed by heating it in a flame. A four inch glass rod is selected which fits it snugly. The tube and rod pass through the second hole and may be brought very close to the conductor. A pointer clip and scale indicate the distance of the inner end of the tube from the conductor. Radioactive substances may be tested by pushing them into the inner end of the tube with the glass rod.

The instrument is used as follows: A light is placed behind a screen which has a narrow vertical slit cut in it. A piece of slotted sheet metal is cut as in figure 3, so as to form a sight which slides along a meter stick or other graduated rod, the latter being supported by a clamp and stand. The sight is adjusted until the reflection of the line of light appears at the center of the glass slip (figure 4). The glass slip should be set in vibration as a

torsion pendulum and its period determined approximately. The original instrument has a period very nearly one second and is very convenient to work with. If a charged body be moved to and fro in the direction of the bell at a rate corresponding to the period of the needle (the copper wire and bell being in electrical contact with the conductor) the latter ultimately begins to vibrate.

With an ordinary hair suspension, the swinging of an electrified ebonite rod at a distance of eight to ten feet will become evident. Also, the electrification due to the removal of a glass rod from mercury is easily shown. A plain glass needle may be used for the above tests, having first imparted a small charge to it. The relative directions of the swings of the needle and excited body determine the nature of the charges. A pendulum with a large metal bob and having the same period as the needle, was so placed as to swing past the bell, thus varying the electrostatic field. However, the results were not so good as those obtained by vibrating the charged body.

In testing radio-active materials such as pitchblende, the conductor is moved as far as possible from the glass needle, a small charge is imparted to it, after which it is again brought near enough to the needle to cause the latter to twist through a large angle. The normal rate of discharge of the instrument is now determined. A small bit of radio-active substance inserted in the glass tube and brought near the conductor greatly accelerates the rate of discharge.

The wide range of sensibility which this instrument offers and the ease with which it may be adjusted, render it of special importance to the experimenter. Its sensitiveness is limited only by the delicacy of the suspension. Its exceptional power of retaining a charge lies in the fact that the charged conductor consists of a cylinder or sphere isolated on some first class insulator such as sulphur, shellac, or amber. It may also be used as a substitute for a torsion balance. The design of the case may be adapted to other instruments.

WITHSTANDS GREAT HEAT.

It has been found by experiment that when the impure forms of bauxite containing considerable iron oxide are exposed to intense heat the bauxite is converted into a solid mass of emery which is so hard that it can barely be cut by steel tools and resists chemical, thermal, and mechanical action to a marked degree. Recent applications of bauxite in brick according to the United States Geological Survey are in the lining of rotary cement kilns, lead-refining furnaces, and basic open-hearth steel furnaces.

THE LAW OF CHARLES BY EXPERIMENT.

By F. R. Gorton,
Ypsilanti, Mich.

No easily workable experiment for the verification of Charles' law is presented in any of the elementary text-books of Physics. The difficulty seems to lie in the fact that no one as yet has suggested a simple method by which the law can be tested without the aid of steam jackets, mercury manometers, etc. The apparatus described below has been given a thorough test by the author and is here submitted in the hope that it will fill this need on the part of high school teachers of the subject.

The devise as shown is made by sealing a burette tube A to the end of a somewhat larger tube B so as to produce a gas space of about 100 c. c. between the closed top and the zero of the graduated tube below. This space is found accurately by weighing the apparatus when filled with water.

In using the apparatus the best results are obtained by keeping the gas in the tube perfectly dry. This is accomplished by supporting the tube in clamps so that the open end is immersed in concentrated H_2SO_4 which is contained in a tall (100 c. c.) measuring cylinder. The acid should stand about 4 cm. in the tube when the gas is at room temperature and the liquid surfaces are brought even by sliding the tube up or down in the clamp. If the cylinder and tube are both attached to a strong stand, the apparatus is very portable and may be used day after day without danger of spilling.

The experiment consists in taking readings on the volume of the confined gas at room temperature and also at the temperature of the outdoor air. The latter is accomplished by simply setting the apparatus just outside the window. A thermometer attached to the stand shows the temperature at which the readings are taken. Of course the liquid surfaces must be brought even before the readings are taken, so that the pressures may be the same. From the observed volumes and temperatures it will be found that a good proportionality exists between the volumes and absolute temperatures. With dry air the error should not be more than ¼%; but if water is used in

place of the acid, an error of as much as 1% may be expected.

By taking readings under the varying conditions of temperature and barometric pressure of different days, a proportionality between the products of pressure and volumes and the absolute temperatures is established. In this case the errors will usually keep below ½%. The cylindrical form of the tube causes the gas to acquire rather promptly the temperature of the surrounding atmosphere; furthermore, it can be raised and lowered in a common clamp.

ELECTROLYSIS OF SODIUM HYDROXIDE.

By G. Ross Robertson,
Polytechnic High School, Riverside, Cal.

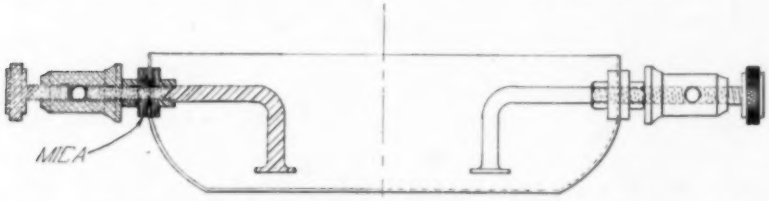
The isolation of metallic sodium by electrolysis is now one of the standard items presented to the high school chemistry student; but as a class or laboratory experiment it is usually left out, probably because it is supposed to be too difficult of performance.

Most of us are in a way familiar with the Castner process, in which molten sodium hydroxide is electrolyzed in an iron cell. In this scheme an iron gauze separates anode from cathode, effectually screening the liquid metal from the anode products. It is entirely practicable to build a small demonstration cell on this plan, as suggested in current works on electrochemistry, such as Hopkins, etc. When this small Castner cell is put into operation, however, so much froth and splashing of the highly dangerous molten NaOH is encountered that in many cases the experimenter will terminate the attempt in something resembling profanity. Commercial NaOH always contains moisture, some of which persists even at fusion temperature. As soon as the moisture is subjected to the influence of the current, the first development is the production of hydrogen and oxygen in the shape of foam. Periodic explosions naturally follow, rendering the experiment one for observation at a respectful though inconvenient distance.

The device shown in the accompanying diagram makes no claim to originality of principle. Even in application it is little more than the original arrangements of Sir Humphry Davy. The fact that it works so simply has led the writer to outline the plan as a demonstration experiment for school use.

The use of a common shallow spun iron pan reduces the foaming to a negligible degree, as only a thin layer of hydroxide need

be used. In addition to the pan, two 20-penny nails, four small nuts, four common washers, four mica washers or bits of scrap mica, and two binding posts of a size suitable for attachment to the nail, complete the list. The nails are bent once at right angles to permit use as electrodes. Two holes are bored in the side of the pan, in any convenient position, to a diameter much larger than the diameter of the nail. The mode of assemblage can be seen from the illustration, care being taken to secure complete



insulation between nail and pan. The head of the nail may approach the bottom of the pan quite closely without harm.

The device as pictured is now placed on a common ringstand, and filled to a depth of four or five mm. with molten sodium hydroxide. A Bunsen burner is of course provided to melt the lye, and later to keep the mass molten in case the current does not do so. After the experimenter has evaporated as much moisture as possible from the lye, the pan is covered and a direct current of ten amperes or more applied to the electrodes. The writer happens to use a D. C. generator at 50 volts, with a resistance of 5 ohms in series, the latter supplied by a common stereopticon rheostat. By elimination of much of this resistance one might use a good battery current of much lower voltage. In fact so high an E. M. F. in electrolysis is quite the exception, and was chosen in this instance only because it was handy.

In first performing this experiment the writer expected the immediate oxidation of any sodium produced, on account of the exposed condition of the cell. On the contrary, but a small percentage is lost. This portion disappears in somewhat interesting pyrotechnic fashion. The larger part of the metal is protected by the tenacious surface of the hydroxide, either floating just beneath this surface or gathering in a mass under the cathode nail. Often so much sodium will gather under the cathode nail-head that it will short-circuit the cell to the bottom of the pan, rendering the pan itself the cathode and producing the subsequent output under the anode nail. In any event a short run will produce enough sodium to make a convincing demonstration. If

one is in no hurry, the cell may be permitted to cool and the contents solidify, after which the globules of metal may be dug out with a penknife.

For a teacher who does not have the necessary taps, dies and other mechanical paraphernalia, a simple modification may of course be toggled up. Simply wrap two battery terminals around two straight nails, clamp in asbestos-bushed burette clamps and suspend in position over an iron pan. This will get results, although the arrangement could hardly be called convenient where temperatures of 400 degrees or more are involved.

If the cell as previously described is thoroughly dehydrated, to prevent injury by spattering, it may be placed—while still in action—beneath an opaque projecting lantern, and shown in a very interesting way to a high school class. If the arc lamp be pulled back, regardless of color aberration in the field of light, a strong illumination may be concentrated on the cathode. In this way the sudden production and expulsion of sodium particles, perhaps with ignition in yellow flashes, affords much interest.

PATENT MEDICINES.

It is about time that secondary school science instructors awakened to the fact that they are charged with the responsibility of bringing to the attention of their pupils the absolute worthlessness and the unmitigated fraud of the innumerable patent medicine nostrums that are now being foisted upon millions of the people of our country. Almost all science instructors know perfectly well that these nostrums are put on the market by people who have really no good motive in selling something that will not cure people of the ills with which they are afflicted. These are money-making schemes pure and simple. Most of these so-called medicines contain poisons of one kind or another, and only in rare cases do they accomplish the results which they claim in their advertisements. If one is ill, the very best plan is to select a good reliable physician and let him prescribe a remedy. It is a crime against mankind for these nostrums to be sold to the general public as medicines. One of the phases of science instruction in our secondary schools should be the education of the pupils, and through them of their parents, against the pernicious evil which these patent medicines represent. Science teachers should take this matter to heart and do everything in their power to eradicate this national evil.

PROJECT TEACHING IN HOME ECONOMICS COURSES.

As a Means of Extending the Laboratory Time and Relating the Work to the Home.

By LOUISE STANLEY,

University of Missouri, Columbia, Mo.

The most dangerous of the present tendencies in Home Economics work is that which is leading us towards courses which are too formal. There is a tendency for the subject matter of any science to crystallize in a definite logical form, in which form it seems to teachers desirable to transfer it as a whole to the minds of the students. Leaving out of consideration for the time being the practical and the disciplinary value of the Home Economics course we must all recognize its educational value. It gives a psychological basis of approach to the same subject matter which we have been giving in a cold dead way. Through Home Economics instruction the students are interested in this subject matter because they see the relation of it to everyday life.

Teachers of other sciences have the same difficulty. They may keep their subject alive by showing the way in which it touches upon life or they may make of it a dull, systematic study of facts or simply a medium for imparting so much information. When we realize this educational value which is present to a greater extent in our work than almost any other we can not but look with horror upon the tendency to make a course in Home Economics quite as dead as some of the pure sciences, when taught as unrelated facts.

In an examination of the reasons why our courses are becoming too formal, it seems to be first due to an exaggerated value attached to abstract information material. We still seem to have the idea of the old fashioned school teacher which gave rise to the poem

"Ram it in, cram it in,
Children's heads are hollow."

Professor Snedden of the Massachusetts State Education Commission calling attention to this fact in a talk at the Home Economics meeting in Cleveland last summer said that we looked upon the minds of children as cold storage plants where so much information is put away on ice. Such information follows a logical outline and is given out in encyclopedic form.

In the second place, some of the difficulty seems to come from a misconception of the relation of theory to practice. We see

in looking over any outline of our work, the lessons are separated into theory and practice. The practice usually takes the form of definite, formal directions for the work to be done, frequently recipes to be cooked, while the theory is more or less related information material. We do not seem quite able to realize that it is possible to connect up our theory and practice. In other sciences we have definite experiments which we dignify by calling experiments or problems through which we work out a large portion of our theory. This same connection should exist between theory and practice in our own work and at the same time the problems or experiments should by their relation to everyday life connect the more theoretical side of school training with the home life of the students.

Unless this is done the course becomes an end in itself and loses sight of the needs of the girl in the home for whom it was originally planned. Home Economics has been the subject which has done more than any other to connect the school with the home, rather than widen the breach between the two; let us do all we can to strengthen the connection.

It was with this idea in mind that I was sent last spring to visit some of the high schools of the South. They wanted a course worked out which would strengthen this relation between the home and the school, and improve the home conditions through the school. These agricultural high schools may be established with the county or the Congressional district as the unit. One in which Agriculture and Home Economics are distinctly the subjects of the course or which are distinctly schools of Agriculture and Home Economics. The others are ordinary high schools with departments of Agriculture and Home Economics. Those of the latter type are more frequently found in town, and while the former may be, they are more likely to be situated out in the country where larger areas of land are available for their use.

Since these schools are so frequently situated in the country and also because of the fact that they are especially adapted to the needs of the country boy and the country girl, it is usually necessary to have in connection with them dormitories for the housing of the students. These dormitories with the surrounding practice farms give an unusual opportunity for the application and the practical working out of the more theoretical lines of instruction in Agriculture and Home Economics. An additional reason is given for this by the fact that the living expenses must be made as low as possible in order to put this means of educa-

tion within the reach of all. In some of these schools the cost for each individual student is as low as five or six dollars a month. This is only made possible by the fact that so large a proportion of the food material is raised by the boys on the farm and so much of the household work is done by the girls.

The amount of time spent in such work by the individual student varies in the different schools. The usual amount is from one hour to two hours per day. In some of the schools outside help is employed. In some, the extra work which can not be done by the students in the required amount of time is taken care of by other students who are paid so much per hour for all work beyond the stated requirement. In this way, and by means of summer work, for which they are paid, many students are enabled to make all of their school expenses.

There is one danger in this. While we see the value of putting this education within the reach of all the country boys and girls we must not fail to recognize the fact that an equally, if not more important item in this plan is that this work is to serve both as the ground work from which the problems in Agriculture and Home Economics are to grow up, and at the same time as the practical field in which they are to be in turn applied. The simple doing of this work is of no special value educationally and in the daily routine of duties, if unsupervised, there will be little more profit than in the performance of these same tasks under ordinary home routine. The argument used by one school man that it enabled the students to get instruction which otherwise they could not afford, is not in any sense in keeping with the spirit of such schools. It should be considered as a part of their everyday work. This does not mean there can be any less period of time devoted to instruction along these lines, but it does mean an extension of the laboratory time devoted to this work.

In such schools, a formal course in Home Economics is possible, but it is not presented in that way when the teacher realizes her responsibility and the necessity of connecting up her own work with the dormitory work in the way outlined above. In these cases one can not but see the value which comes from this extended practical work. The need for similar training is recognized in those schools in which the boys who are receiving industrial training are sent for stated periods into an industrial plant to come in contact with practical problems and apply to them the more theoretical school training.

In such schools seems to lie the solution of the problem which

will enable us to connect up the home and the school more closely. A large per cent of these girls will go home and apply there the things which they have learned are necessary and desirable in their daily instruction and life at school.

In most of our high schools we have control of the students for only the time that they are with us, but can we not make the training we are giving them during this time more a part of the lives of the girls by letting a part of the laboratory work extend over into their homes? There are various movements on foot which have this as their aim. There is, so far as I know, no definite project teaching in Home Economics anywhere in our country. In Massachusetts, however, much of the agricultural work is taught in the form of projects. The boys, instead of taking problems which are to be worked out entirely in the school laboratory or garden, choose problems which can be worked out in their own home garden, coming, of course, to the school for help as it is needed.

It seems to me that it ought to be possible for us in this way not only to extend and vitalize our Home Economics teaching but also to give it a much more definite connection with the home. I realize there are many difficulties, but I do not believe there are any more than those encountered by the men interested in industrial training, or in agricultural training for boys, and we see in both these cases the difficulties have been surmounted.

I believe the result of such a method would be first, that the courses will be adapted more directly to the needs of the individual girls. They will be made more directly applicable to the home life of the girls. We frequently do not recognize that a course which is adapted to the needs of a girl in Chicago does not fulfill the needs of a Missouri girl, nor does the girl in the Hyde Park high school need the same course as the girl in one of the down town districts.

In the second place, I think such a plan will change our method of teaching. Instead of imparting information which is to be applied in practice, which practice is frequently so far removed, that the information acquired is forgotten long before it is needed, and no definite connection between the two is established, we shall teach by giving the girls something to do, and only giving them the information when they feel the need for it to help solve the problem in hand. When these problems are taken directly from the home life of the girls we can see how neces-

sarily, the course will become more closely connected with the everyday life of the homes of the girls.

Some illustrations as to ways in which this plan might be carried out are probably not amiss.

First of all I feel that discussions of the division of the income can much better be approached through a study of the distribution of the various items in the expense accounts of the individual girl. There can be no objection to such a discussion when put on a percentage basis. In calculating how much her food and shelter costs the girl is brought face to face with the household problem of division of the income.

But take a simpler problem—we are attempting to teach the importance of a sufficient amount of water in the daily dietary and impress upon the girls how much we each need. Will they not get this fact more easily and will it not mean more to them if each one is required to keep account of the amount they are drinking? In case this amount is too small they should be taught how to form the habit of drinking the correct amount.

Meal planning can much more advantageously be taught if the problem is the real one of planning the family meals. The selection of clothing should find a very practical basis. Care of the house might easily be taught by assigning definite problems to be done at home and reported upon. House decoration through the rearrangement of the girls' own rooms. The possibilities are endless. Can we not have some discussions of ways in which such projects have been successfully carried out?

TRANSYLVANIA COLLEGE.

At the annual meeting of the Board of Curators of Transylvania University held June 9th, a resolution was unanimously adopted, changing the title of the institution from that of *University* to *College*. Hereafter, the first institution of higher learning founded west of the Alleghenies, and which has just closed its 117th session, will be known as Transylvania College.

Measured by every standard, the session which closed June 10th was the most satisfactory in the history of the college. Two hundred and fifty students were enrolled, Ewing Hall, a residential hall accommodating 129 men, was dedicated, a new heating and lighting plant erected, and other substantial improvements made.

For a greater period than almost any college in the South, Transylvania has given a full four-year college course based on four years of high school preparation. From the enthusiasm manifested by the alumni at the recent Home-Coming, Transylvania will doubtless render a far greater service to the cause of higher education during the second century of her life than during the first one hundred years.

THE TRISECTION PROBLEM.

By James H. Weaver,
West Chester High School, Pa.

This problem, along with those of the duplication of the cube and the quadrature of the circle, has furnished the popular mind with unlimited material for speculation. Its origin is not, however, surrounded by romance as is that of the duplication problem, nor does it furnish such a long list of would-be solvers as the quadrature problem, yet it will always be classed as one of the famous three, and as such is worthy of consideration. One of the first solutions of this problem was given by Hippias of Elis who invented for this purpose the curve called the quadratrix.[1] Later we find Archimedes giving a solution[2] while several others are mentioned by Pappus, some of which he discusses at length. In the following discussion we shall give the solutions that were best known among the Greeks, keeping as far as possible the Greek point of view and method of attack. (It is here assumed that the best known solutions are those preserved by Pappus and the one by Archimedes.)

It must be borne in mind though, that the trisection problem did not die with the Greeks. For in later times we have on record solutions by Newton, Descartes, Clairaut, Chasles and others[3]; while Felix Klein[4] deals with the impossibility of a solution by means of ruler and compass. But Klein was not the first to discuss the possibility of such a solution. Even the Greeks knew something about the classification of problems as the following passage from Pappus indicates (*Pappus,* ed. Hultsch, Berlin, 1878, page 270. Hereafter when any reference is made to Pappus this edition will be understood to be the one referred to): "When the old geometers wished to trisect a plane angle they stopped for this reason. We recognize three types of geometric problems, of which one is plane, a second solid, and the third linear. Those therefore that can be solved by straight lines and circles, for this reason are called plane, since the lines by means of which problems of this sort are solved have their origin in a plane. The solution of those problems that assume one or more of the conic sections is called solid, for in order to construct these it is necessary to use the surfaces of solids, or at least conic sections.

[1] Gow, *Short History of Greek Mathematics,* p. 162.
[2] Heath, *Works of Archimedes,* Lemmas, No. VIII.
[3] Ball, *Mathematical Recreations,* p. 186; also Kempe, *How to Draw a Straight Line.*
[4] *Three Famous Problems,* translated by Beman and Smith, Ginn and Co.

A third species of problems is left, which is called linear, for besides the curves that we have mentioned, others having a varied origin, which are originated from surfaces less regular, and from complicated motions, are employed for construction. Such curves are those which are discovered from loci on a surface ..... Also others of this species are spirals, quadratrices, conchoids and cissoids, and geometers who are not mediocre seem to be in error if they solve a plane problem by means of conic sections or other curves, and in general if they solve anything by means of something unrelated ..... Thus when problems differ among themselves the old geometers were not able to solve the problem of the trisection of the angle when they tried it by means of plane problems, because it is by nature solid, for they were not yet accustomed to use conic sections."

The following is the solution of Archimedes mentioned above. In a circle of which the center is D, Figure 1, draw any chord AB and produce it to C so that BC equals a radius. Join CD cutting the circle in Z and produce CD to meet the circle again in E. Then the arc AE will be three times the arc BZ.

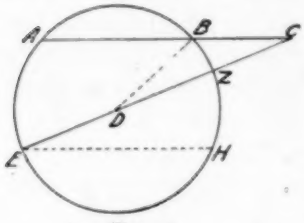


FIG. 1.

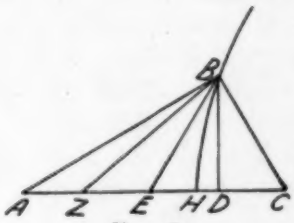


FIG. 2.

This solution as well as the first one of those mentioned by Pappus depends upon the insertion of a line of given length between two given lines. This was a method studied quite extensively by the Greeks, the term used by them in this connection being inclinations. Apollonius had written two books on inclinations which Pappus discusses in Book VII of his Collection, giving a general notion of the contents of the two books and some lemmas on them. In his introduction to the lemmas Pappus states that one of the problems of the books was to take two lines given in position and insert between them a line of given length which passes through a given point.[5] The first method that is given by Pappus is the one that is discussed by Cantor

[5]For a full discussion of inclinations see *Works of Archimedes*, T. L. Heath's Edition, Introduction.

and has recently appeared in this journal[6]. For that reason it will be omitted here. The second method found in Pappus depends on conic sections. The solution will be given following the original as nearly as possible to show some of the properties of conics that the Greeks considered essential. It is as follows: Let there be given a straight line AC and from the points A and C let AB and CB be so drawn that the angle ACB is double the angle CAB, then the point B is on a hyperbola.

Let BD be drawn perpendicular to AC and let DE be cut off equal to CD, draw BE. Then angle BEC = angle BCA = 2 angle CAB. But angle CAB+angle ABE = angle BEC, therefore angle CAB = angle ABE, and BE = AE. Let EZ = DE, then $CD = {}^1/_3CZ$. But let $CH = {}^1/_3$ AC, therefore H will be given $CH-CD = {}^1/_3 (AC - CZ)$, i. e., $HD = {}^1/_3AZ$, and because $BE^2 - EZ^2 = BD^2$, and $BE^2 - EZ^2 = DA \cdot AZ$, therefore $DA \cdot AZ = BD^2 = 3AD \cdot DH$. Therefore the point B is on a hyperbola. . . . . And also the hyperbola described in this manner will cut off one-third of the arc of a given circle, as is easily understood if A and C are ends of the arc.

That the point B is on a hyperbola may be easily verified by analytical methods. Pappus draws the conclusion that B is on a hyperbola from Apollonius, Conics 1, 21,[7] where the above condition is developed.

The next solution is one of great significance because it is the first recorded use of the focus and directrix with respect to conic sections.[8]

"Some by other reasoning have explained the solution of the trisection of an angle or of an arc without inclinations. Let the arc be cut in any ratio for it makes no difference whether we cut an arc or an angle.

Let it be done and let BC be one-third of AC and let AB, BC, AC be drawn and then angle ACB = 2 angle BAC. Let CD bisect the angle ACB and let the perpendiculars DE and BZ be drawn, then AD = DC and AE = EC, therefore the point E is given. Now because AC : CB = AD : DB = AE : EZ, and by alternation AC : AE = CB : EZ. But AC = 2AE. Therefore CB = 2EZ, and $CB^2 = 4EZ^2$, that is $BZ^2+ZG^2 = 4EZ^2$. Now because the points E and C are given and the perpendicular BZ is drawn and given and the ratio $EZ^2 : BZ^2+ZC^2$ is given, the

[6]Vol. XIV, p. 790.
[7]Heath's *Conics of Apollonius.*
[8]*Pappus,* Book IV, Prop. 34.

point B is on a hyperbola. But it is also on the arc of a circle, therefore it is determined."

In the above solution if we consider DE as a fixed line and C as a fixed point then the distances from B to the line ED and from B to the point C will have the ratio 2, that is, the construction is possible by means of a hyperbola of eccentricity 2 :

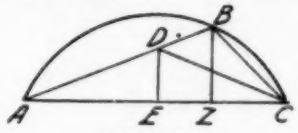


FIG. 3.

The directrix is the line DE and the focus is C for one branch and A for the other branch. Both branches will make the trisection of the arc complete.

The two following solutions show how to divide an angle in any ratio by means of the quadratrix and the spiral of Archimedes. Before giving them, however, a description of the curves in question will be necessary. The description of Pappus is as follows: "For the quadrature of the circle by Dinostratus, Nichomedes and some other more recent writers a certain curve is used. It is called the quadratrix by these men and has its origin in this manner. (See note above.)

Let there be given a square FBKN and about B as a center let the arc KLF be drawn and the line BK so moved that the point B remains fixed, while the point K is drawn along the curve KLF, moreover, the line KN always remaining parallel to its original position follows the point K as it moves along KLF and in the same time that the line KB traversing uniformly the angle KBF, that is, while the point K traverses the arc KLF, the line KN is drawn along KB. That is, the point K traverses KB. It happens therefore that KB and KN arrive at BF at the same time, and while the two lines are thus moving, they intersect in some point which describes the curve KAC. This curve is enclosed by the lines BK, BF and the arc KLF and it is useful for the quadrature of the circle. The principal property of the curve is this, that if any line as BAL is drawn to the arc, then the whole arc KLF : LF = BK : AE. This is evident from the construction of the curve.[9]"

"The spiral of Archimedes is constructed in this way. Let there be a circle whose center is B and whose radius is CB and let

[9] *Pappus*, page 252.

the line BC be so moved that the point B remains fixed and the point C moves uniformly on the circumference of the circle and at the same time a point starts from B and proceeds uniformly to C and arrives at C when CB has made one revolution of the circle. Then the point in BC when BC is revolved will describe a curve as BZDC of which the origin will be the point B and the curve is called the spiral whose principal property is this. If any line as BZ is drawn to the spiral and produced to H, then total circumference : CFH = CB : BZ. The proof is evident.[10]"

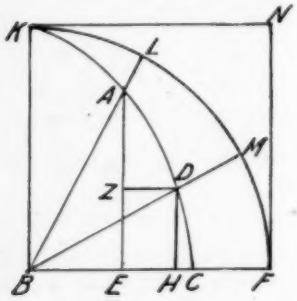


FIG. 4.

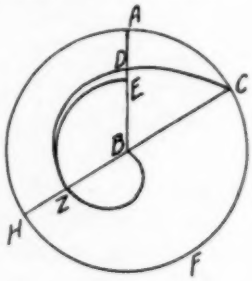


FIG. 5.

To divide an angle or an arc in three parts is solid as we have shown, but to divide an arc or an angle in any ratio is linear and this has been proved by recent writers, but it will be illustrated by us by two methods.

Let there be an arc KLF (Fig 4), which it is desired to cut in a given ratio. To the center of the circle let there be drawn the lines LB and FB and BK perpendicular to FB, and through the point K let there be drawn the quadratrix KADC cutting the line BL in A, and let the perpendicular AE be so cut in the point Z, that the ratio AZ : ZE equals the given ratio, in which we wish to cut the angle and let ZD be drawn parallel to BC and the join BD be produced to M, a point of the arc, and the perpendicular DH be drawn. Now on account of the property of the quadratrix AE : DH, i. e., AE : EZ = angle ABC : angle DBC, therefore AZ : ZE = angle ABD : angle DBC = arc LM : arc MF.

The arc AC of a circle ABC is cut in this manner (Fig. 5).

From the center B the lines AB and CB are drawn, and from the origin B is described the spiral BZDC, whose generatrix is BC (the generatrix is the moving line that generates the curve)

[10] *Pappus*, page 235. For a complete discussion of the properties of the spiral, see *Works of Archimedes*, ed. Heath, Cambridge Press.

and let the given ratio be DE : EB and through the point E about the center B let there be described the arc EZ cutting the spiral in Z and let the join BZ be produced to H, a point of the circumference HAC, then on account of the property of the spiral, DB : BZ, i. e., DB : BE = arc CHA : arc CH, therefore DE: EB = arc AH : arc HC, therefore the arc is cut in the given ratio."

THE HIGH SCHOOL AN EDUCATIONAL CENTER.

It has been commonly supposed that the high school building in the various cities of the country, is a self-contained institution, and that it is placed where young people in their "teens" gather to learn something about Greek and Latin, mathematics and the sciences, for the fundamental purpose of developing their memory and reasoning faculties. However good these things may be in themselves, they are but a part of the complete education and development of the young person.

There are studies being taught in the territory of the high school which, to particular individuals, are just as important as a knowledge of any subject that they may secure by attempting to follow the prescribed course in the school. The school should be an educational center, from which all types of learning may radiate, and in which something may be learned which bears upon all educational phases of life. All of the pupils' knowledge and educational life is not secured in the high school. For instance, many boys may have been working in machine shops, at the carpenter's trade, or in some office or manufacturing establishment. The girls may have been taught by the mother in the home with reference to house-work, or they may have been operators in telephone exchanges, or have done office work. They, both boys and girls, may have been engaged in many other lines of activity which might be mentioned. All of these have had their influence on the young mind, and the young people have been educated in these directions in a degree proportionate to the amount of time that they may devote to the study included in the regular high school course.

Having spent more or less time on these subjects outside of school, which in reality will materially assist in securing their bread and butter in later life, the pupils should have credit for this work toward their graduation from the high school. The day is not far distant when all high schools will be obliged to give credit for this outside work. It is not the continual grind on the inside subjects that is altogether educating the boy and girl. The work done outside has very much to do with his development educationally; and its value frequently is greater to the individual than that which he may get inside the school. High school instructors should keep this point in mind, and endeavor to bring together all phases of the pupils' development so that each phase will be given its true share of credit toward the pupils' graduation from the high school.

SYMMETRY IN ELEMENTARY GEOMETRY.

By M. O. Tripp,
Olivet College, Michigan.

This article is written for the purpose of pointing out to teachers of mathematics the fact that the subject of symmetry is of more importance than one would imagine from reading the average textbook. There are two little books which the teacher will find especially helpful in giving him a broader grasp of symmetry and the various ways in which it may be used to develop geometric intuition. One of these is *Henrici's Elementary Geometry* or *Congruent Figures,* published by Longmans, Green & Co., and the other is Mahler's *Ebene Geometrie* belonging to that remarkable list of cheap texts (80 Pf each) known as the *Sammlung Göschen,* published in Leipzig. These books are written in very simple language and it will well repay any teacher of mathematics to study them carefully.

It is of great advantage in the teaching of geometry to make the student feel satisfied with proofs. This can generally best be done by getting the pupil to see the truth of geometric statements through mental or physical inspection of the figures, rather than by long drawn out logical reasoning. Symmetry is a means of bringing points, lines, and other parts of certain figures into correspondence in a thoroughly concrete manner.

Let us consider central symmetry as a means of studying the properties of certain geometric configurations. Any plane or solid figure is said to be symmetric with respect to a point O, called the centre of symmetry, when any line drawn through O and terminated by the boundaries of the figure is bisected at O. This idea of symmetry evidently agrees with that of rotation of the figure through 180^0 about an axis passing through O, and perpendicular to the plane of the figure, in case the points of the figure all lie in a plane. It is well for the student to keep in mind both of these ways of considering central symmetry in the course of his geometric work.

Thus the intersection of the diagonals of a parallelogram is a centre of symmetry of the parallelogram. Likewise the intersection of the diagonals of a parallelepiped is the centre of symmetry of the parallelepiped. We may now introduce two new definitions: (1) A parallelogram is a quadrilateral which has a centre of symmetry. (2) A parallelepiped is a hexahedron which has a centre of symmetry. From (1) we may prove, that the opposite

sides are parallel, and hence (1) harmonizes with the usual definition. Also from (2) we may prove that the opposite faces are parallel and hence (2) agrees with the usual definition. It is an interesting exercise for students to find out what polygons and polyhedra have a centre of symmetry and which have not.

By means of symmetry we may prove that the opposite sides of a parallelogram are equal. Thus to show that $AB = A'B'$ we take the figure OAB and revolve it 180° about an axis perpendicular to the plane of OAB and passing through O, the centre of symmetry. Therefore A falls on A′ and B on B′, and consequently the line AB coincides with A′B′. By revolving OBA′ we find that $BA' = AB'$.

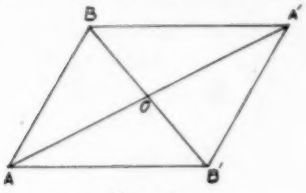


FIG. 1.

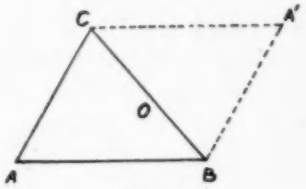


FIG. 2.

Henrici brings out very clearly the relation between congruent figures and figures symmetrical with respect to a centre. Any two congruent plane figures can always be placed, and that in an infinite number of ways, in such positions that they are symmetrical with regard to a centre.

Thus from the triangle ABC we may construct the congruent triangle A′BC by completing the parallelogram on AB and AC and hence the two triangles have central symmetry with respect to O.

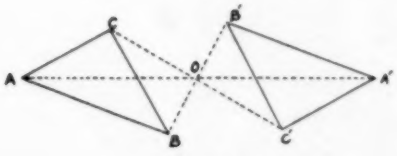


FIG. 3.

Again in Figure 3 we may choose O as any point in space, and then produce CO, AO, BO so that $CO = C'O$, $AO = A'O$, $BO = B'O$.

The two figures, ABC and A′B′C′, are congruent and symmetric with respect to O as a centre of symmetry. It is evident that any plane figure may be treated in a similar manner. Accordingly symmetric figures are merely congruent figures in

special positions. The triangles in Figure 3 are a special case of projective triangles in perspective position.

Considerations concerning axes of symmetry lead to the discovery of many properties of figures. We define the axis of symmetry of a figure as a straight line a such that, if from any point A on the boundary of the figure a perpendicular be dropped on a and produced to D so that AD is bisected by a, the point D lies on the boundary of the figure. This definition evidently harmonizes with that of revolving the figure about a through 180°.

Let us use the idea of axial symmetry in proving that any point on the bisector of an angle is equally distant from the two sides. Thus the bisector of the angle is an axis of symmetry. Hence if from any point D in AH, we drop a perpendicular, say DE, on one of the sides then by revolving ADE about AH as an axis, ED takes the position E′D, and hence the two perpendiculars from D on the sides of the angle are equal.

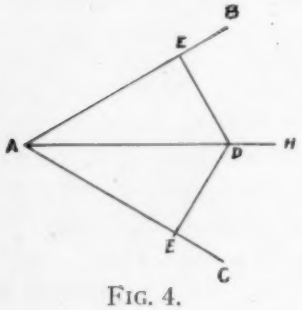


FIG. 4.

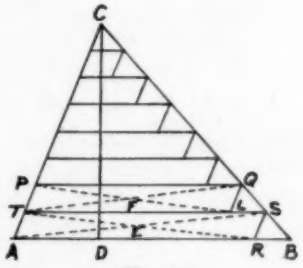


FIG. 5.

A triangle has one, three, or no axis of symmetry. A quadrilateral which has one axis of symmetry is either a kite or an isosceles trapezoid. The rhombus and rectangle have each two axes of symmetry, while the square has four. Students will find it interesting to investigate regular polygons with reference to axes of symmetry. A solid may also have an axis of symmetry. For example, the three lines joining the midpoints of the opposite faces of a rectangular parallelepiped.

In solid geometry the plane of symmetry should receive more attention than it usually does. In fact our textbooks pay little or no attention to the subject. A plane of symmetry of a figure is a plane x such that, if from any point A on the boundary of the figure, a perpendicular be dropped upon x and produced to A′ so that AA′ is bisected by x, the point A′ lies on the boundary of the figure. An excellent concrete example of a plane

of symmetry is the ordinary plane mirror in which object and image are symmetrically situated with respect to the mirror. Students will find it interesting to discuss the number of planes of symmetry of the various solids. The rectangular parallelepiped may have three, five, or nine planes of symmetry; and students may be readily led to tell under what conditions these various cases exist.

The study of symmetry is often of great help in determining the centre of gravity of a homogeneous mass. It is evident that if a body have a plane of symmetry this plane must contain the centre of gravity. Likewise if a figure have an axis of symmetry the centre of mass must lie in this axis. Also if a figure has a centre of symmetry it is the centre of mass.

We can show by means of symmetry and centre of gravity that the three medians of a triangle are concurrent. In Figure 5 divide the altitude CD of the triangle ABC into a number of equal parts and draw lines TS, PQ, etc., parallel to the base. At the points S, Q, etc., on BC, draw parallels to AC, thus forming a series of parallelograms—ARST, TLQP, etc. These parallelograms have centres of symmetry at the intersections of their diagonals, viz., E, F, etc. If now we let the number of parts into which CD is divided increase without limit, the points E, F, etc., approach a limiting position on the median from C to AB. But the centre of gravity of the two parallelograms, ARST and TLQP, lies on the line joining E and F. Hence H approaches a limiting position on the median. The centre of symmetry of each parallelogram approaches a limiting position on the median; and the centre of gravity of all the parallelograms taken together also approaches a limiting position on the median. But the centre of gravity of all the parallelograms together approaches the centre of gravity of the triangle ABC as a limiting position. Hence the centre of gravity of the triangle ABC must lie on the median to AB. Since the centre of gravity also lies on the median to BC, it must lie at the intersection G of the two medians; and hence the third median, that is, the one to AC, must pass through G.

By placing greater emphasis upon symmetry in our high-school work, geometry will be made more practical, because of the various applications to physics, mineralogy and architecture. Moreover, the concrete form which geometry takes when presented in this way adds greatly to the interest of the students.

RATIONAL VS. MECHANICAL METHODS IN TEACHING MATHEMATICS.

By Jos. V. Collins,

State Normal School, Stevens Point, Wis.

It might be supposed that there was only one side to the question of rational vs. mechanical methods but this view is probably far from true. Certainly a good argument can be set up for mechanical methods, and it is probably quite true that many teachers can do better with the mechanical methods than with the rational ones. When the Editor asked the writer to prepare something for the readers of School Science and Mathematics his first thought was that he could be of most help to others by touching on various aspects of the work of teaching which his long experience had brought to his attention. But later he concluded he could say much of what he had in mind in better organized form under the above caption.

If a rational method of teaching uses too much time in explanation so that bright pupils can get their work in class and dull ones do not get drill enough, or if there is not sufficient uniformity in classroom methods so that pupils can not tell what will be expected of them at the next recitation or if too much or too little ground is covered, the rational teacher's results may be inferior even much inferior to those of the mechanical. However, if the rational teacher uses a reasonable amount of a common sense, his work ought to be far more satisfactory than that of the mechanical teacher.

There are two ways in which mechanical teaching is most easily recognized—first, in the teacher's conduct of the recitation, and second, in his close adherence to the textbook used, with stress laid rather on the what, than on the why. With reference to the first of these it can be said that in this country there is an established form of recitation widely used. The tendency is for teachers to use this form following it pretty closely. Probably most teachers do not think much about this matter, taking the form of recitation for granted as the one properly to be employed. In this form of recitation when the teacher first meets his class he asks for difficulties that may have been met in the preparation of the lesson and explains them briefly. He then sends either the whole class or a section of the class to the blackboard to solve assigned problems. After these problems have been solved, they are explained by those who solved them. At the end of the hour the new lesson is assigned

and suggestions for its preparation are given. This form of recitation is used day after day with little variation unless more of explanation is given on some days than on others. A half dozen or even a dozen clearly defined forms of recitation are available which can be used either alone or in all sorts of combinations and adapted to different topics; and the progressive rational teacher should investigate and experiment with them until he finds the combination best suited to his personality and the needs of his class. The mechanical teacher easily falls into the routine employed when he was a pupil in a secondary school, and clings to it tenaciously; the rational teacher is not satisfied to follow extreme conservative lines and desires to know whether there is not a better way.

Taking up the topic of mechanical teaching of subject matter which follows the textbook used closely, let us see what rational teaching would substitute. Rational teaching lays stress on the whys and wherefores of things as well as on the whats and the hows. A balanced proportion of these is needed in good teaching, and is essential to good teaching. Since the what and the how naturally come first, it is natural to lay more stress on them. There is always a chance that they may be overemphasized and the why slighted or ignored. Textbooks themselves very often slight the why and wherefore and when this happens, the teacher is the more excusable for ignoring them, bad policy in the end though it be.

To illustrate: Authors on geometry do not explain why a line is bisected in what to the pupil is a strange and roundabout way. A few moments suffice to show that a line can not be bisected by measuring it, and taking half of its length to get its middle point since a line taken at random is quite sure to be incommensurable to the measuring unit. Similarly a string can not be used to get the length of the line and be then doubled on itself to get its half since a string stretches. Turning then to the means at disposal in geometry, viz., a straightedge and a compass, we are led naturally to the ordinary plan for bisecting a line.

Authors on geometry rarely or never say anything about fallacies in reasoning; though dealing with them plays a prominent part in rational teaching of geometry. It is related that after Euclid had written his *Elements* and had used them in classroom instruction, he was led to write a book on fallacies. Doubtless any teacher of geometry of experience could do the same. But it is a pity that the book of fallacies did not come down to

us as an integral part of a textbook on geometry. It is perfectly easy to show the student that a converse proposition is not necessarily true if the proposition itself is true by a simple illustration. All pygmies are men does not give us conversely all men are pygmies, though if converse propositions were true, this last statement would be true.

In algebra, textbooks commonly explain the place of the axiom in the solution of equations once for all, and then depend on the teacher to keep up the reference to them as equations are solved. Experienced teachers follow this course since they know that unless it is done, the instruction becomes largely mechanical. Inexperienced teachers follow the textbook and thus lay stress merely on the what and the how of on them and also the why and wherefore. Three or four of our recent authors lay proper stress on the place of the axiom in the solution of equations but the others not, and the latter list includes some whose books have had a very wide sale.

Algebra is generalized arithmetic and at the same time the alphabet and grammar of all subsequent higher mathematics. Rightly taught it is a language, a science, and an art which functions closely with most other knowledge; poorly, that is, mechanically taught, it is a barren waste, a dreary desert of knowledge with few or no oases in it to cheer the pupil on to its mastery.

A mechanical teaching of proportion in arithmetic is an abomination. The presentation of proportion as found in many arithmetics is based on the ancient idea that a ratio is not a fraction. The whole colon and double colon notation can be cut out and the problem set down for immediate cancellation far easier than it can be run through the colon notation grove. Mechanical teaching retains such absurdities; rational teaching throws them on the scrap pile. As suggested in the preceding, authors as well as teachers can be set down in two classes, the mechanical and the rational. The mechanical author puts the old matter in some slightly different form or arrangement or he eliminates some part of the old which was too difficult, but leaves the subject to all intents and purposes as he found it; the rational author while taking his material from the older textbooks somewhat as he finds it in them, tries to apply the recent teaching of psychology and other science, to his presentation, and tries to adapt his presentation to the present-day needs of pupils. He smooths the difficult places in the older texts, emphasizes the whys and where-

fores, knowing that this will add materially to the educative value of the study, and adds humanizing features, such as historical notes in connected form, pictures, etc. The rational author may make mistakes by going to some extreme, but it is clear, he ought to be preferred to the mechanical author by the progressive teacher.

In a talk at Columbus two or three years ago, the writer set forth what he conceived to be the main steps in learning mathematics. Of these the second was the idea of repetition. A few words on this topic seem appropriate in this connection. A long time ago, say seventy-five or a hundred years ago, textbooks on mathematics contained very few exercises. Later the number was greatly increased, as in such books as those of Ray and Robinson. Later still the number of exercises was again increased as in Wentworth's texts. Latterly in some parts of the country the number has again been increased in the texts used. Now it is clear there must be some golden mean somewhere beyond which it is not wise to go. Requiring pupils to solve an excessively large number of exercises of the same kind is evidently running to the mechanical. The pedagogy underlying the plan is to have the pupils learn by mechanical repetition. The rational teacher would expect better permanent results from a more rational psychological plan for learning mathematical material. Such teaching may yield good marks in entrance examinations, depending, of course, on the character of the examinations set; but will it yield results when the pupil gets out into life, or into sophomore and higher mathematics in college?

A writer in one of the Reports of a Meeting of the Teachers of Mathematics in the Middle States and Maryland seems to doubt the wisdom of overemphasis on mechanical repetition. He raised the question as to whether it was better to solve 36 problems of a certain kind each day for 10 days or to work one of each kind, each day, for 360 days. The truth is, the best use is made of repetition when after the first introduction of a topic the review of it is spread out over a longer period. The most rational teaching is that which presents a constant review of all that has preceded. This is to a very considerable extent if the order of topics approved by long experience is followed and if this is supplemented by the proper kind of checking and proving in arithmetic and algebra.

There is one respect in which the writer is disposed to prefer the mechanical to the rational, viz, as regards defending math-

ematics as having educational value to the student. There is a tendency in this age for pupils themselves to ask, what is the value or help I am to get out of this study? It would seem to be the rational thing to explain the practical value the study has for the pupil. Really, it is probably wiser to say that the pupil is not in position to understand properly this rather deep question, and that if reasons are given they are more likely to be misleading than helpful. If the quality of truthfulness were up for discussion and debate it would not be very difficult to raise doubts in the minds of hearers as to whether it would not be better to lie occasionally. If reasons are given they are likely to be convincing to the pupil only when they are really narrow and unsatisfactory. Probably the best way to bring the matter to a finality is to say that secondary mathematics is found in practically all the curricula of all countries and that those countries which have made the deepest study of the psychology underlying education favor increasing the requirement in mathematics rather than decreasing it.

Euclid even in his day had this conundrum propounded to him. A boy asked, "What do I gain by studying geometry?" Euclid answered the question wisely by telling his slave to give the boy some coppers, saying, "He has to be paid for what he learns." Modern teachers of mathematics having no bag of money, not to speak of a slave, perhaps can secure boxes of bonbons or a summer camp trip for their precious changes who want some compensation for what they learn by securing the coöperation of the parents. I remember once while Professor Sylvester of Johns Hopkins was lecturing about some topic, he was reminded by something of this question of the practical, and immediately his face became cloudy and he declared in impassioned words that he wanted it understood that what he was giving had absolutely nothing whatever of the practical in it, and he gloried in the fact. In his excitement he whirled around like a whirling dervish, his hair standing out in remarkable fashion impelled by centrifugal force. Very likely some of his associations in the past had made him touchy on the subject. Perhaps no man who has ever lived in America has done more than he to develop mathematics, and thus indirectly the applications of mathematics.

The reason why some half-baked teachers want to throw out geometry and algebra is easy to discover. Some pupils find great difficulty in learning mathematics; for their sakes, and to

make their studies easier for the others, throwing the mathematics overboard furnishes an easy solution of the problem. The real solution of this problem for other studies quite as well as for mathematics is to allow the mathematically defective to elect other studies with the advice and consent of the mathematics teacher, and allow history defectives, grammar defectives, etc., to do the same. It is usually not difficult for teachers to tell when pupils have reached their limit of fruitful study in subjects. To drop such pupils out of classes is a distinct advantage to all the parties concerned. This solution of a vexing educational problem leaves in the curriculum one of its essential constituents, the mathematical studies.

A PROCTOR OR ADVISER FOR BOYS.

In our larger secondary schools the boys, in most cases, have no instructor to whom they may go for advice in the larger things that center about the school. We will admit that the individual class teacher is oftentimes ready and willing to act in the capacity of adviser and superintendent of the boys' activities. Likewise the principal will assist in matters of this nature, but he has other things which demand his attention, and cannot devote any considerable time to this particular phase of secondary school work.

The writer therefore pleads before all Boards of Education for the appointment of a proctor or director of boys' activities, whose business it shall be to look after the general welfare of the boy from a moral, social and physical point of view. He will be able to correlate the various activities that may be or should be carried on in the school. He will have his hands on and be in touch with all of such matters. He will be the adviser of the individual boy as well as of any group of boys touching the different activities that may arise, and he will be in a position then to direct some phases of school affairs in a way that cannot be done by the principal, and certainly not by the individual teacher. In athletics he will be able to lend a hand in directing the coaches and in representing the school in various athletic contests. Also in contests of other sorts—debating, mathematical skill, social activities that may take place between schools—he will be the man to direct matters to a great extent.

There is a growing demand for a position of this sort, as people are beginning to realize that the schools are for the purpose of developing all-around boys and girls, and not for the purpose of developing freaks in Greek or mathematics or some other subject. And what is said here concerning the boy is equally true with reference to the girl. It is hoped that progressive teachers the country over will seriously consider this suggestion and use their influence in putting the plan in operation in their particular schools.

NATURE-STUDY AND AGRICULTURE IN RELATION TO EDUCATIONAL MOTIVES AND PURPOSES.

By H. N. Goddard,

State High School Inspector of Agriculture, Madison, Wis.

We are told that on the occasion of the visit of a great preacher to Athens, he found the "Athenians spending their time in nothing else, but either to tell or to hear some new thing." In education we have had much of this search for new things. The search has led to much foolish waste of educational energy, to many silly fads and to much educational exploitation of children. At the same time it has led to progress. What we need most now and what we have always needed in education in order that real progress may be rapid and sure is *educational balance*—the ability to sift out and retain what is tried and best in the old and unite with it what is sane and reasonable in the new. Changing social, economic and political conditions are bound to call for revised methods and the use of new materials. At the same time, it is necessary to divest ourselves of useless traditions. Our educational system has received and assimilated, with more or less success, many of these new things. Whatever indigestion or educational dyspepsia may have resulted, we have, nevertheless, made rapid growth and, today, America may honestly boast of one of the best educational systems in the world, although we may yet have many things to learn from other countries. A long list of hobbies has successively occupied the educational stage. The kindergarten, object teaching, correlation, child study, Herbartianism, recapitulation, industrial arts, Nature-study, plays and games, the Montessori method, vocational education and many more have appeared one after another. We have attempted to apply the psychology of interest and attention, of habit, of sense training and apperception, of adolescence and of the biogenetic conception. We have striven to make education practical. In these days we are socializing school subjects, motivating our teaching and vitalizing the school. Good has no doubt come from all of these but the astonishing thing about it all is that the children on whom all of these have been tried, though possibly slightly distorted or intellectually stunted at times, have usually come through in a pretty good state of intellectual preservation. At the same time they have grown up and have been able to meet the duties of life with a greater or less degree of success. All this is perhaps a great tribute to the powers of growth and development in the average child.

Whatever good may have been gained from each of these notions, it is nevertheless true that many leading educators are yet saying that much of our present education is formal, isolated from real life problems and comparatively ineffective. While I do not wish to assume the part of the critic, yet I think we must confess that there is at least room for further improvement. One of the greatest dangers in all new educational ideas is the tendency to systematize each according to the notion of the adult mind, until most of the life and value have been squeezed out of it for the child. Prof. Charters of Missouri University says in a recent book that every subject when first introduced into the curriculum had a vital value, but that so far, not one has had much life left after submitting to the systematizing process. Nature-study came in response to a keen demand of child-life and child-development, but it immediately fell a prey to the scientists, the "integument men," the anthropologists, the course of study-makers, until its very life was gravely threatened. Fortunately, it has refused to be stereotyped, but as a result, it occupies a comparatively small place in most schools. It has been left for the boy scout movement to really adapt it to the nature of a boy. The fixed program and the formal class exercise made it impossible for the school to do this.

More recently agriculture has demanded attention and there is much encouragement that this will not only realize its own vital value, but that it may do much in vitalizing all the other school work. There is some prospect that school work in this subject may actually be able to function in the practical life of the community. Nevertheless, there is grave danger that it, too, may be a victim of the standardizing habit and as a result may lose a large part of its vital value. In order that it may not, it is necessary that we should develop a clear understanding of its values and of the methods and motives which must be depended upon to arouse interest, secure effort and give the work life value. My task is to point out some of these values and motives and show how they become modified as we pass from the Nature-study to the agriculture viewpoint.

Before attempting to do this, let us look for a moment at the present educational situation. We are trying, in these days, to adjust ourselves to the idea of education in a democracy. This means universal education. As faith in this idea has become deeply fixed, we have been breaking away more and more from old traditions. At the present time, we are asking in educational

circles as never before, how can we make education really efficient in meeting the problems of democracy? We no longer look upon the school as an institution for a selected few. The function of the school is, therefore, no longer to train a few people for so-called learned professions, or fit a small number for higher institutions, but it is to provide a training which will best lead every boy and girl into intelligent, useful and successful living. We have come to recognize that our present educational system has tended to train pupils away from the life they are living, rather than to fit them for it. As a result, country boys and girls have too often been anxious to get away from the farm, while young people generally have built up an ambition to find some life easier than their parents have had. A false line of separation has grown up between the work necessary for a livelihood and those activities which contribute to enjoyment. The present viewpoint of education is away from these notions. According to this new viewpoint, the highest product of the schools is not the one who knows the most or who has the greatest mastery of certain subjects. It is rather the person who is most able to meet the duties of life efficiently, and at the same time appreciatively. This means making a living, but it means also the discharging of the duties of citizenship and the capacity for wholesome use of the leisure of life. This viewpoint is well expressed in the ideal of the Danish high schools in the following: "It is not the business of the high schools to give a few facts of this subject or a few facts of that, so much as to awaken the minds of its pupils, to arouse in them a feeling of brotherhood, to give them a knowledge of themselves and of life. We want our pupils to say when they leave: 'Now will I go back to my work more fully realizing the meaning of it and more deeply feeling the dignity of it.'" Such a view seems to demand first of all a general education. This should give command of the tools of knowledge. It should develop right habits and appreciations and put meaning and intelligence into life. It should further prepare for the best citizenship and the highest social service.

In addition to this general education, the school should also provide some training to help every person to be able to gain a competent livelihood in some line, which will not only furnish proper financial support, but which will also be suited to the tastes and talents of the individual. For this purpose the school should help the pupil to find himself with reference to some vocation—that is, he should discover what life activities make

the strongest appeal to his tastes and talents. When this is done the school should further provide opportunity for him to develop some skill in the work of this field. This should not be merely mechanical skill, but it should include an intelligent and appreciative understanding of the work. It has come to be the firm conviction of many educators that these two phases of education should not be carried on apart from each other, but they should be so blended that the general education shall furnish a large knowledge and a wide perspective, for an understanding and appreciation of the vocation, while the vocational work helps to vitalize and motivate the general work. These two should not only be closely blended at any particular time or period, but the one should lead gradually into the other as the school course progresses. In the early grades the vocational makes, of course, a minor, and perhaps hardly perceptible, appeal. However, it finds a sudden and rapid awakening in the upper grades and finally becomes strong and even predominant in the upper years of the high school.

With these views of education before us, I am now ready to consider the main point of my topic. The Nature-study fits, of course, most completely into the early part of the scheme. Its appeal to the child is strong because of its wide freedom and because of its pleasing relations with his own pleasurable activities. The child at this stage is stimulated most strongly through his senses and Nature furnishes an inexhaustible array of new and strange materials which please the eye, attract the ear, stimulate the imagination. Again, all his racial tendencies lead him to love the fields, the woods, the streams and the out-of-doors. Furthermore, since his own organism finds most natural and most pleasing expression through activity, he finds his most ardent interest in activity in the world about him. Nature, and especially living Nature, furnishes this activity in never-ceasing cycles. This appeal is especially strong because of the constantly changing scenes and situations which Nature affords. A large part of every child's education consists in making conquest of this strange and ever-changing world. The schools have shown far too little recognition of this fact. This interest in activity soon develops an ardent desire to discover what things in Nature can do, and then the child wants to know how they do it. It should be noted that living, changing Nature and the spacious out-of-doors make the strong appeal. The school has been exceedingly slow in adapting its stereotyped classroom

methods to these well-known child interests. Indeed, much high school botany and perhaps other science, which might have made a strong appeal to interest and effort, has been dead and fruitless because of failure to present this side. It is not information about Nature or even stories of Nature that appeal most strongly to the child. What he wants is sympathetic acquaintance with Nature and an understanding of her ways. This should lead to a right attitude which is more moral than intellectual, and which should finally develop both a knowledge and a spirit leading to the preservation of useful things and control of those which are harmful. Educationally this study not only develops sympathetic knowledge, but provides also a most vital intellectual training, and a concrete experience which is able to vitalize much of the more formal work of the school.

As pupils advance toward higher grades, new interests become dominant and should lead to a modification of the work. These new interests take the form of an eager desire to appropriate Nature's resources and to be able to manage and control her forces. Likewise the study of wild animals makes a strong appeal to love of adventure and thrilling experience. Woodcraft finds a ready response. At the same time, the desire for ownership or possession and for the profits of productive enterprise begins to appear and grows stronger as the upper grades are reached. The boy comes to want to be a man and wishes to imitate man's achievements. As this interest becomes predominant, it gives a motive which should gradually modify the work. Gardening work and the raising of plants may well have formed a part of the Nature work considerably before the seventh and eighth grades. Such work as a part of the Nature-study should be given larger attention as the grades advance and should gradually be merged into what may be really called agriculture in the seventh and eighth grades. Formal agriculture should not be started before the beginning of the seventh grade. The work before this time should be generalized with the Nature-study, and not taken up as a distinct subject.

This agriculture of the seventh and eighth grades should not be treated as an informational subject or even as elementary science with simple observation and experiment. There is little motive for such work. It should be treated rather as an industrial art. We hear much about the general culture of a brief informational course in agriculture to help pupils to appreciate farm life and to learn how food products are raised.

I am extremely skeptical about this idea. Real motive is lacking and such study will almost certainly lead to indifference if not positive dislike. The only way to appreciate the farm and appreciate how food products are raised is to get into the soil and make it give up, to your labors and care, the golden treasures of fruit, of grain or of vegetables. There is already too much appreciation of the farm by those who don't want to live on it but who prefer to wear fine clothes and keep their hands clean in the city. The work should have for its central aim the carrying out of certain surveys and projects relating to farm practice which is adapted to the conditions of the locality. With this practical work, motivated and limited by it, there should be some instruction work. I am not at all certain that any instruction work should be given except as the practical work furnishes the motive and gives the basis for it. Our plan of a daily recitation period carried over the usual school year is poorly adapted to the needs of this work. We have yet to devise effective methods of doing this work in the upper grades. Unless we can do this, agriculture is likely to fail. As a purely informational subject or even as a science subject with suitable experimental work, I have little faith in it, either in the upper grades or in the high school. Treated in this way it is likely to be made as dead and as devoid of interest as the specialist's type of physics is to the average high school girl. Elementary science, teated with a fair degree of skill, would be far preferable. Even a poor treatment would be better, since this would not drive young people away from the farm. We have had far too much of this kind of agriculture since it has been introduced into the schools. The only motive on which the work can be based successfully is this desire for ownership and possession, and the interest in utilizing Nature's resources for some worth-while result. A boy likes to do any piece of constructive work which brings to him something worth possessing. The interest is heightened in the case of raising farm or garden products by the growth process, which affords interesting change and development from day to day. Again, an exhibit of products and the final sale of what was produced serves to greatly emphasize the worth-whileness of a project, and this strengthens the motive for effort on the part of the pupil. Rivalry in itself is a powerful motive with us all in any activity we engage in. Besides the boy at this age wants to be a man and therefore to achieve what men are achieving. When he

can not only raise more corn or potatoes than his schoolmates, but can beat out his father and the neighbors, the motive again is greatly intensified. All these motives are lacking in textbook or laboratory agriculture.

Again, the agriculture work in the upper grades may be looked upon as of a prevocational nature. The pupil is given a chance to find out what practical agriculture is, and to learn what results may be expected from such work. He thus learns whether this is what he likes or can do most successfully. Later, when he enters high school he is ready for this or for some other line of work.

In the high school it is believed the agriculture should become strictly vocational, that is, it should be for the purpose of enabling the pupil to develop a larger intelligence and greater skill in farm practice, with the definite idea of making this a life work. Not that he must here make any such final decision, but that he may be trained at least for this in case he continues to find himself adapted for it. We have now a number of high schools in Wisconsin where such courses are being given and where, as a result of the course, many boys are planning to make farming their work. Here again the central line of work should be the project in which the student actually carries through some piece of farm practice and, as far as possible, secures a profitable result. Here in the high school, however, the course may be much strengthened and the understanding of problems may be greatly widened by the application of the knowledge of the sciences, of economics and other high school branches. The chief motive, however, will be still much the same, viz: the carrying out of productive work for the securing of a worthwhile result. The larger knowledge and better understanding of problems may make some appeal, but this will be secondary. Again, simply studying about agriculture and performing laboratory experiments will fail to make any adequate appeal to the high school pupils.

The laboratory for agriculture should be mainly the soil and the real farm products. Certain laboratory experiments are, indeed, desirable when properly related to actual experience, but agriculture of purely informational and laboratory character has, I believe, no more value and can arouse no greater motive in the high school than an informational course in manual training or domestic science or typewriting. The true place of agriculture, as of these other subjects, is that of an industrial art.

Such treatment will not only interest the pupil but it will have high educational as well as vocational value.

We have tried to show the place of the Nature-study and of the agriculture in the curriculum and have tried also to show how the one merges gradually into the other. We have further tried to show how the Nature-study motive changes, not suddenly, but gradually, until a distinct motive provides the true basis of the agriculture. Nature-study has its large place in the earlier grades, where it should be a generalized study of the child's natural surroundings. The desire to do something for a practical result grows rapidly and leads the pupils to give an eager response to the industrial arts. At the beginning of the seventh grade, the agriculture makes a most valuable subject for such treatment. The work has a prevocational value in the upper grades, and this gradually changes into a more strictly vocational value in the later years of the high school, where the work should still be treated as an industrial art or vocational subject linked up with and strengthened by the general studies of the high school, especially the sciences. There should be definite instruction work, but this should be linked up with and motivated by the practical doing of suitable projects related to the farm. Some of these projects may be school projects but there should also be home projects, which actually carry the school work over, so that it functions in the home. It is the business of those charged with agricultural work to devise effective methods of accomplishing these results. The fixed methods of the schools as they are today are the least adapted to this work of any of the industrial subjects. At the same time the right kind of agricultural work is a most fundamental need. A purely informational course or a course treated purely as a science is in my judgment of very doubtful value, since it lacks motive. Such cultural value (whatever people may mean by that term) can be obtained far more effectively by the right kind of science work. Agriculture is an industrial art, and treated as such has high educational value, if indeed, it is not itself also in the truest sense highly cultural.

THE SCHOOL GARDEN.

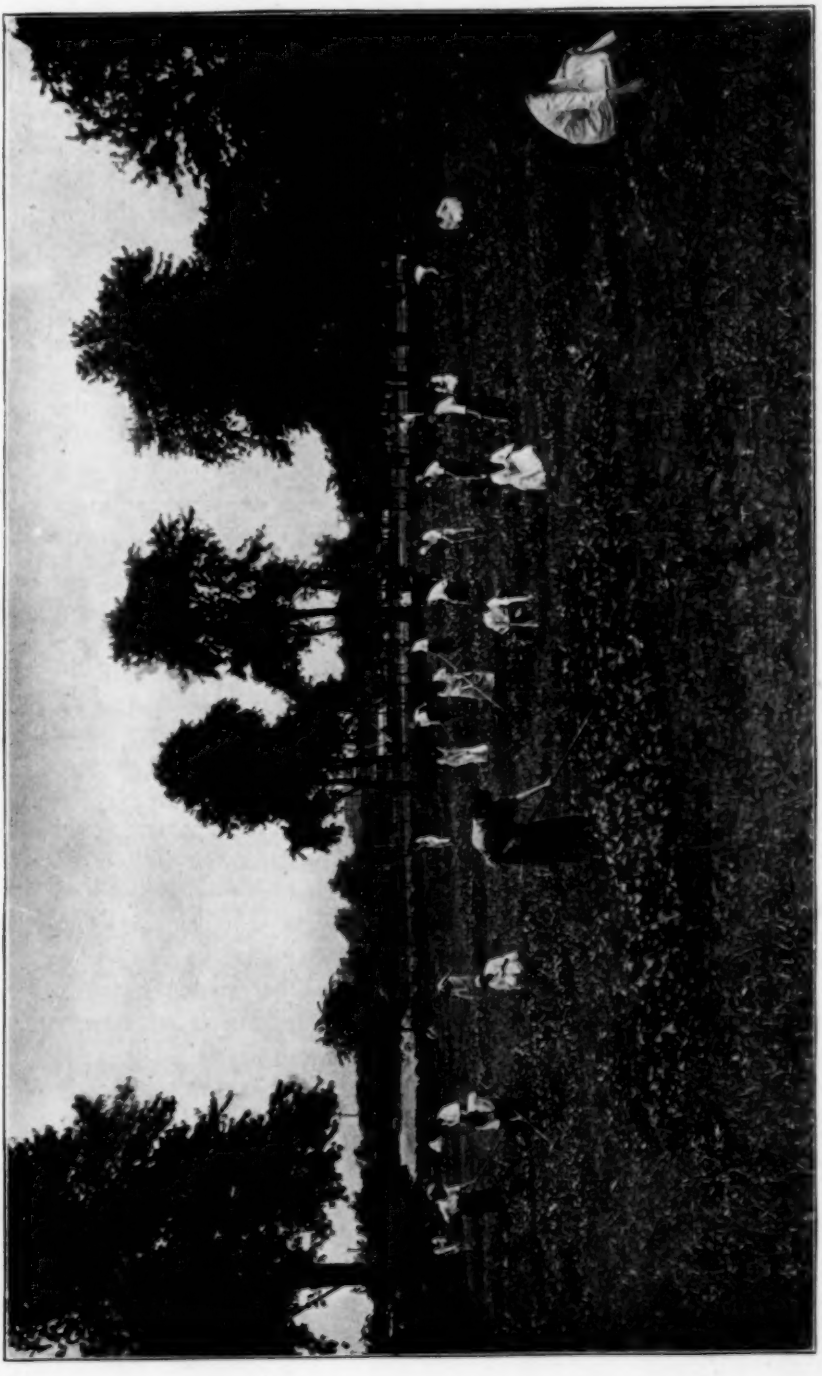
By Ellen T. Sullivan,
La Grange, Ill.

The botany pupils of the Lyons township high school carry on a school garden as a part of their regular course. Last year work in gardening was given the same credit as field trips for collecting and becoming familiar with the spring flowers.

Since the ground was used by us for the first time last year, we attempted to find out the condition of the soil. The pupils obtained a pail of earth from five or six different spots in the field. They dug down about seven inches below the surface and the top and lower layers were then thoroughly mixed. About a pound of this mixture was sent to a chemist in our town who analyzed it for us without charge. The analysis showed a lack of limestone and phosphorus, but we wished to know the necessary amount of each per acre, and so we sent the analysis to the Agricultural Department of Illinois. We were advised to use one ton of ground limestone and one-half ton of rock phosphate to the acre and this they spread on the ground.

However, all this preliminary study of the soil is not necessary. Usually a good dressing of decomposed barn yard manure is very satisfactory, but it will give better results if applied in the autumn and then plowed under and allowed to remain until spring. However, if the soil is naturally moist it is likely to be sour and plants and nitrogen fixing bacteria cannot live long in acid soil. This condition can easily be corrected by covering the ground with a thin coat of air-slacked lime and then working it in well. To determine this condition, pupils can test a handful of slightly moistened soil by means of blue litmus paper. If the soil is sour, the paper turns red.

We allowed pupils a choice between the field trips and the garden. The class consisted of 57 girls and 46 boys, and 24 girls and 30 boys selected the garden. We were given the use of vacant lots near-by—more than an acre. The school authorities paid for the plowing and harrowing of the soil, and the pupils did the rest. When the soil was dried sufficiently so that a handful obtained at a depth of three or four inches from the surface fell apart through the fingers, after being grasped tightly, it was considered fit for planting the seeds. The size of the individual gardens varied from 500 square feet to 900 square feet.



High School Gardens.

Each student removed all clods and stones from his plot and made fine and level the upper three inches of soil with a hoe and steel-tooth rake. It was then ready for planting, but pupils were advised to plant at least some vegetables that would mature before the close of school. Radish, lettuce, peas, and onion sets were found very satisfactory. Other things were also planted; namely, carrots, beets, Swiss chard, beans, tomatoes, potatoes, and sweet corn.

Pupils were given instructions about planting. The radish seeds were sown in drills buried not deeper than one inch nor less than one-half inch and about one-half inch apart. When the plants showed the second set of true leaves, they were thinned to stand about two inches apart in a row. The lettuce, like the radish, is a hardy plant and does well in early spring. The seeds were planted at the same time and in about the same manner as the radish and the earth packed firmly over the seeds so as to bring the moist soil in contact with them. But when these plants were well up, they were thinned to six inches apart in a row.

Carrot, beet, and Swiss chard plants are hardy and so the seeds were planted about a week after the radish and lettuce, but of course they require a longer season to mature. Beans can neither endure frost nor stand transplanting well and so they were not planted until the severe frost was past. They were then placed in rows one foot apart and buried two inches deep at intervals of six inches.

The tomato requires a long season but while it cannot stand the frost it can be transplanted easily. About the middle of March the seeds were planted in boxes in the schoolroom and when the first true leaves appeared, they were transplanted to stand at least two inches apart. The latter part of May they were put in their permanent location in the garden in rows eighteen inches from each other and the plants about twenty inches apart in the row.

Many of the pupils not only supplied their homes with early spring vegetables but also sold some of their produce.

LIVE CHEMISTRY.

By H. R. Smith,
Lake View High School.

We are much encouraged in this work by the number of contributions recently sent in, and also by the appreciative words of teachers who are finding value in the published experiments. We ask again for helpful suggestions and criticism from anyone interested in this work.

You can do much study on foods with profit at this time of the year. The Pure Food Laws are slowly improving conditions for the production and sale of food products. Foods are of better average quality than they were ten years ago. The public needs to be better informed on food quality and more critical in comparing real quality with the advertised quality. A little effort in the chemistry classes will help the cause greatly. Have you found out what your State Food Commission is doing? The Illinois Commission will deliver free illustrated lectures in Illinois on "Labels and Their Meaning," "Food Sanitation," "Milk: Its Care and Dangers," "Flies and Their Relation to Disease." The last two are arranged for motion pictures.

The Chemistry Section of the Central Association of Science and Mathematics Teachers, under the direction of S. R. Powers of Terre Haute, Ind., is preparing a survey of methods and conditions of teaching chemistry in the Central states. Such a survey forecasts a general improvement in the teaching of the subject. We trust that it may be realized; and it will, if teachers will respond. The list of questions are neatly typed in pamphlet form at some length, but the questions are so worded that the answers may be brief. We urge that all teachers of Chemistry answer the questions and send them in, in order that the work may be most fruitful. If you do not receive a copy, ask Mr. Powers for one.

Receipt for Homemade Baking Powder.

To be Done Outside and Results Compared in Class.

½ lb. cream of tartar.

¼ lb. baking soda.

1 tablespoon cornstarch. Sift six times and keep in an airtight can.

Using the above receipt, compare the price of baking powder made at home and that bought at the grocer's. Tell which you would prefer to use and give reasons.

How much cream of tartar would you need to use with one pound of baking soda?

When this baking powder is used, how much Rochelle salts would be formed?

How much carbon dioxide would be given off?

In using baking soda, would you use sweet or sour milk? Why?

In using baking powder, would you use sweet or sour milk? Why?

How does carbon dioxide cause cake to rise?

What determines the amount of soda one must use in baking a cake?

What kinds of baking powder are there beside the cream of tartar baking powder?

Alice M. Child,
East Division High School, Milwaukee, Wis.

A Live Student.

In the department of Live Chemistry in School Science and Mathematics for June, 1914, we briefly outlined a method for making a

souvenir stick-pin from a silver coin. A student in our laboratory has extended the experiment to another metal. While visiting at the home of his uncle a few weeks ago, he noticed an old watch case in the rubbish heap. Thinking that the case might contain some gold, he brought it to the chemical laboratory, and placed it in dilute nitric acid. The porous mass that did not dissolve, he rightly concluded to be gold. He placed this on a piece of charcoal, added a little borax, and in a few minutes, with the blast lamp, he had a beautiful gold bead. For twenty-five cents, a local jeweler inserted a gold-plated stick pin and the result is a solid gold article of jewelry, worth possibly somewhere between five and ten dollars. Other students have since been looking into rubbish heaps and barrels for old watch cases and cast-off jewelry, and that is the reason for offering this paragraph to the Editor of Live Chemistry.

NICHOLAS KNIGHT,
Cornell College, Iowa.

SOME SIMPLE ORGANIC COMPOUNDS.

MATERIALS:

$KC_2H_3O_2$; NaOH; HCl; lime water; methyl alcohol; piece of copper wire 30 to 40 cm. long; resorcin solution (1%); conc. H_2SO_4; sweet milk; potassium bichromate; ethyl alcohol; carbon tetrachloride (CCl_4).

PROCEDURE:

(a) *Marsh Gas.*

1. Mix about 10 g. of powdered potassium acetate with three times its weight of soda lime. Place the mixture in a flask provided with a one-hole rubber stopper and delivery tube. Heat strongly over a wire gauze with a luminous flame. After the air is expelled, collect the gas in a test tube over water.

2. Thrust a burning match into the mouth of a test tube of the gas. Fill another tube half full of gas, raise it from the water and immediately apply a flame to the mouth of the tube. Complete the equation: $CH_4+2O_2 \rightarrow ?+?$.

3. Place some of the material remaining in the flask used as a generator in a test tube and test it for the presence of carbonates by adding HCl and allowing the gas generated to bubble through lime water. Complete the equation:

$$2KC_2H_3O_2+2NaOH \rightarrow ?+?+?.$$

(b) *Carbon Tetrachlorid.*

1. Moisten a filter paper with five cc. of alcohol or kerosene. Place in a crucible and ignite. Pour over the flame 1-2 cc. of carbon tetrachlorid. Explain what causes the flame to be extinguished. Warm 2 cc. of carbon tetrachlorid in a deep clay crucible. Lower a lighted candle or a burning splinter of wood into the fumes. Explain the result.

How is CCl_4 related to marsh gas? It is used in cleaning and in dissolving fats and oils instead of gasoline or benzine. Why?

(c) Formaldehyde.

1. Cut a piece of heavy copper wire about 40 cm. long. Twist half the length of the wire into a close spiral around a lead pencil. Mix 2 cc. of wood alcohol with about five times the amount of water. Place the mixture in a test tube and stand the tube in a beaker of cold water in order to keep the contents cool while the reaction takes place. Heat the copper spiral strongly in the upper Bunsen flame. When it reaches a red heat, thrust it quickly into the tube of dilute alcohol. Remove the spiral, dip it into some cold water, and then repeat the whole process five or six times. What change takes place in the copper spiral while it is held in the oxidizing flame? Complete these equations and explain:

$$CH_3OH - 2H \rightarrow HCHO;\ CuO + 2H \rightarrow ? + ?.$$

2. Divide the liquid from (1) into two parts. Add to one portion a drop of resorcin so'ution and mix thoroughly. In a test tube place 5 cc. of conc. H_2SO_4. Incline the tube and pour the previously prepared mixture down the side of the tube so that it lies on top of the acid. A red ring, Hehner's ring, will form between the two.

3. Divide a sample of sweet milk into two portions. To one part add the remainder of the formalin solution. Set both portions aside for 24 hours, or until the pure milk is sour. Why is the use of formaldehyde in foods prohibited?

(c) *Acetaldehyde.*

Dissolve 2 g. of potassium bichromate in 20 cc. of water. Acidify with 5 cc. of dilute H_2SO_4. Add 1 cc. of ethyl alcohol. Warm gently. The solution becomes green, due to the formation of chromic sulfate. Notice the odor of the gas evolved. Potassium dichromate readily liberates oxygen when treated with sulfuric acid. Complete this equation and explain what has taken place.

$$CH_3CH_2OH + O \rightarrow ? + ?.$$

How does this experiment differ from the one in which acetic acid was made by the fermentation of sugar or starch? In what way is it like the one just performed on the making of formaldehyde? Could both the aldehydes made in this experiment be changed into acid? What are some of the uses of acetaldehyde? Complete the equations:

$$CH_3CHO + O \rightarrow ?;\ CH_2O + O \rightarrow ?.$$

Name each of the compounds indicated in the equations.

Lime, Cement, Mortar and Concrete.

MATERIALS:

Portland cement; fresh lime; sand; gypsum; plaster of Paris HCL; NH_4OH; $(NH_4)_2C_2O_4$; KCNS; tin pan or box with oil or grease to cover the inner surface; cracked test tube or old bottle.

PROCEDURE:

(a) *Cement.*

1. Place about 3 g. of Portland cement in a beaker. Add 50 cc. of conc. HCl. Warm gently for five minutes. The insoluble residue is largely silica. Place a small portion of it on a glass plate and rub with the rounded end of a glass rod.

Filter the solution and to a portion of the filtrate add NH_4OH until it turns red litmus blue. What does a white precipitate indicate? Complete these equations:

$$Al_2O_3 + 6HCl \rightarrow ? + ?;\ AlCl_3 + 3NH_4OH \rightarrow ? + ?.$$

Filter the precipitate off and add 5 cc. of a solution of ammonium oxalate to an equal volume of the filtrate in a test tube. Complete these equations and explain:

$$CaO + H_2O \rightarrow ?$$

$$Ca(OH)_2 + 2HCl \rightarrow ? + ?;\ CaCl_2 + (NH_4)_2C_2O_4 \rightarrow ? + ?.$$

Test another portion of the first filtrate from the cement for Fe by adding a few drops of KCNS.

2. Mix a quarter of a cup of cement with a cup of sand. Moisten this mixture with a quarter of a cup of water and mix thoroughly. Place in a small pan or box previously coated on the inside with oil or grease. Tamp with a pestle or a rounded piece of wood until a little water stands on top of the mass. Add more water if necessary. Mix a thin paste with a little cement and water and spread over the top smoothing it down with a knife blade. Set aside until the next day. Remove the cement block from the mould and explain what has caused it to set.

(b) *Lime and Mortar.*

1. Weigh out about 5 g. of fresh lime. Add 150 cc. of boiling water. When the reaction has ceased, add HCL until the solution is acid to litmus. Warm the solution in a breaker for five minutes and filter through a weighed filter paper. Dry at 100°C. and reweigh. The insoluble material is largely silica. Calculate the percentage of insoluble material in the sample. For good lime it should not exceed 10%.

2. Mix twenty g. of lime previously slacked in water with an equal amount of sand and enough water to make a thick paste. Set aside to harden. Will it reach its greatest strength immediately after setting? Why? Write the equations which represent the setting of mortar and the slacking of lime. How is lime made?

(c) *Plaster of Paris.*

1. Heat about 5 g. of gypsum ($CaSO_4.2H_2O$) in an evaporating dish or crucible until it becomes a white powder. Cool and mix with a small amount of water. Set aside until it hardens. Show why these changes have taken place.

2. Mix twenty g. of plaster of Paris with enough water to make a thin paste. Dip a strip of cloth into the paste and roll it into a cylinder. Al'ow the cloth to dry. Pour the remainder of the paste into a test tube or small bottle, packing it down with a pencil. Notice what happens when the plaster sets. Could concrete be used in moulds if it acted in a similar way? Explain what causes the plaster to set.

DISCUSSION:

What are the following and for what are they used: concrete, reinforced concrete, kalsomine, mortar, p'aster; limestone, lime water, whitewash. Mention several uses for plaster of Paris. How are plaster casts for broken limbs made?

REFERFNCES:

Kahlenberg and Hart *Chemistry of Daily Life.*

Farmers Bulletin No. 235—*Cement, Mortar and Concrete.*

Carbon Tetrachlorid as a Cleaning Agent.

Test the solubility of cocoanut oil, paint, butter, cold cream, grease from meats, and other common fats and oils in gasoline or benzine mixed with carbon tetrachlorid in the ratio of two parts of CCl_4 to five parts of gasoline or benzine by volume. For ordinary household use, three parts of CCl_4 to ten parts of gasoline will give a satisfactory mixture. Try to burn 1 cc. of the mixture by placing it in an evaporating dish and applying a lighted match.

The class should read the article entitled "Coquetting with the Fire Fiend" in the *Good Housekeeping Magazine* for February, 1913.

ROY W. KELLY,
Pacific Grove High School, Cal.

ALCOHOL AND ITS APPLICATIONS.

APPARATUS:

Beaker, bottle, glass rod, graduated cylinder, 100 cc. hydrometer, iron spoon, lens, microscope with slide and cover glass, one large test-tube, two small test-tubes with corks.

MATERIALS:

Alcohol 95 per cent. Alcohol dried by standing over lime in a well closed bottle, denatured alcohol, wood alcohol, copper wire No. 20, iron wire No. 20, cigar lighters, filters, iodine, lime water, powdered rosin, shellac, sodium, hydroxide about 1:20.

Caution: Test-tubes containing alcohol shou'd be heated by placing them in a beaker of water. The direct flame should never be used for heating

alcohol or any other combustible liquid. The burner should be extinguished while working with alcohol.

(a) PHYSICAL PROPERTIES:

Record in your notes those properties of alcohol which are evident upon inspection. Is it a viscous liquid? Note the odor. Would a liquid which was not volatile have any odor? Compare the volatility of a'cohol with that of water by placing a drop of each of the two side by side on a filter and noting the time taken for each to disappear. Which is the more volatile? Which, therefore, should have the lower boiling point? Refer to the table on p. 410 and test your prediction. Using a hydrometer the 100 cc. graduated cylinder, determine the specific gravity of alcohol. An alcoholmeter can be used if avaliable. This is a hydrometer which reads directly in percentages of a'cohol by volume.

(b) BEHAVIOR OF ALCOHOL WITH WATER:

To 1cc. of alcohol in a test tube add ten drops of water. Is water soluble in alcohol? Now add 1cc. of water. Finally add 5cc. of water. Is alcohol soluble in water? Is it possible to obtain two layers? Refer to your notes of Exercise 30 (d) in which you determined the behavior of ether and of carbon disulphide toward water. How does the behavior of alcohol differ from that of these liquids?

(c) ALCOHOL VARNISHES:

Place about 0.5 gram of shellac in a dry test tube and add 5cc. of alcohol. In another dry test tube cover about 0.5 gram of powdered rosin with 5cc. alcohol. Warm both tubes by dipping them into warm water—not with the flame. Shake.

When the solids have dissolved take two cigar lighters and dip one into each liquid. Let dry and dip again. When dry examine with a lens and compare the dipped portion with the untreated wood.

(d) TINCTURE OF IODINE:

Place four crystals of iodine in a test tube and add 2 cc. of alcohol. Warm by placing the tube in hot water not with flame. Does the iodine dissolve? In making the commercial tincture, potassium iodide is added in addition, to increase the solubility of the iodine in the alcohol.

(e) TEST FOR ALCOHOL IODOFORM:

To the warm liquid obtained in (e) add dilute (1:20) solution of sodium hydroxide drop by drop until the color disappears. Cool under the faucet. The solid which separates is iodoform. Note its odor and appearance. What are its formula and uses (text p. 258)? If a microscope is available, place a drop of the liquid with the crystal on a slide, protect with a cover-glass and examine with a power of 200-400 diameters. What is the shape of the crystals?

(f) DETECTION OF HYDROGEN IN ALCOHOL:

Fill a bottle with the coldest water obtainable and dry the outside with a towel. Fill the iron spoon two-thirds with alcohol which has been dried by standing over lime. Ignite the alcohol with a match and hold the bottle over the flame. Result? The presence of what element is shown? Why is it necessary to use dry alcohol in this experiment?

(g) DETECTION OF CARBON IN ALCOHOL:

Empty the bottle, place in it 2 cc. of lime water and tilt the bottle until every part of the interior is wet with lime water. Hold the spoon with the burning alcohol in the bottle for about half a minute. Withdraw the spoon, cover the bottle with the hand and shake. Result? The presence of what element is shown?

(h) PARTIAL OXIDATION OF ALCOHOL:

Wind 30 cm. of No. 20 copper wire around a lead pencil to a close spiral. Place 1 cc. of alcohol—no more—in a large (8 in. x 1 in.) test tube. Hold

the copper spiral with an iron wire. Heat it in the upper part of the burner flame until it glows. Then drop it into the test tube. The odor produced is that of aldehyde (text p. 200).

Repeat the experiment, using wood alcohol instead of ordinary alcohol. The same copper spiral can be employed. Note, with caution, the piercing odor of formaldehyde (text p. 202).

Repeat once more using denatued alcohol (text p. 198). Why is the odor of formaldehyde obtained in this experiment?

ROBERT H. BRADBURY,
Southern High School, Philadelphia.

MATHEMATICAL ARTICLES OF INTEREST.

BY H. C. WRIGHT,
University High School, Chicago.

LONG, EDITH. Reply to "What Is the Present State of Experience with Coördinated Courses in High School Mathematics?" *The American Mathematical Monthly,* XXI, No. 7 (September, 1914), 239-242. The idea is expressed that the mathematics instruction in the high school must be built upon the experience of the child in connection with the measurement of lines, areas and solids, first brought into use by drawings so as to appeal to the eye and then by expression in algebraic symbols. Thus the development of the mathematics has as a basis something tangible. In this reconstruction there is need of the coöperation of the university teacher. A sounder pedagogical basis for the mathematics is desired.

ARCHIBALD, RAYMOND CLARE. Remarks on Klein's "Famous Problems of Elementary Geometry." *The American Mathematical Monthly,* XXI, No. 8 (October, 1914), 247-259. The author read this book with a class in geometry for teachers. He gives, in somewhat condensed form, his notes in this connection. He finds the little book of worth to high school teachers because it contains (1) the exact statement of the proof of the necessary and sufficient conditions for construction with ruler and compasses; (2) the proofs of the impossibility of solution by means of ruler and compasses, of the famous problems—trisection of an ang'e, duplication of the cube, squaring the circle; (3) full discussion of Gaussian polygons; (4) general considerations on algebraic constructions, the integraph, and the geometric construction thereof, and other facts of interest in elementary geometry.

BARNS, CARL. The Mathematician in Modern Physics. *Science, N. S.,* XL (November 20, 1914), 721-727. The article is from an adress given at the dinner of the American Mathematical Society, in Providence, R. I., September, 1914, on the occasion of the one hundred and fiftieth anniversary of Brown University. The speaker reviewed the progress of the experimental physics during the past forty years of his experience. He came to think that both the physicist and the mathematician, in the main, follow the method of trial and error; that both develop from idea to idea.

MAIR, D. B. Mathematics for Non-Specialists. *The School World,* XXI, No. 188 (August, 1914), 281-284. The writer describes three motives as giving rise to mathematical activities: (1) Systematizing motive; (2) Wonder motive; (3) Utility motive. His p'an is utilitarian, to choose the material for its human interest. He makes geometry the staple of the earlier stages of mathematical education. Algebra then becomes a handmaid to geometry. Trigonometry and arithmetic are two other handmaidens. To these he adds calculus to broaden the non-specialistic range; also statics and the system of geometry invented by Gaspard Monge, the system of representing three-dimensional figures by means of plan and elevation.

COATES, J. V. H. Notes on the Teaching of Congruence. *The School World*, XVI, No. 191 (November, 1914), 411-414. The author deals with four points—(a) the number of pairs of equal parts necessary for congruence; (b) the four cases of congruence; (c) the equalities which may be deduced from the congruence of triangles; (d) the application of congruence to the proof of constructions and theorems. He introduces the work by two sets of exercises—(1) the copying of a given triang'e; (2) the construction of a triangle from certain data. His discussion is illustrated by a pair of non-congruent isosceles triangles on opposite sides of a common base.

MILLER, G. A. Recent Mathematical Activities, *Popular Science Monthly*, LXXXV, No. 5 (November, 1914), 457-463. The writer reminds us of the work of the Paris Academy of Sciences; of the International Commission on the Teaching of Mathematics; of the publication of a large encyclopedia devoted to pure and applied mathematics being published in parts, in German and in French; and of the effort being made to publish the comp'ete works of Leonhard Evler.

MCCARTY, A. L. The Metric System in the United States. *The Educational Outlook*, Vol. 2, No. 2 (July, 1914), 95-99. This is an interesting historical sketch of the various efforts and methods to have the metric system adopted by Congress prior to such action in July, 1866. The writer calls attention to the use of millibars on the reverse side of the weather maps, issued by the United States Weather Bureau. He mentions the difference of opinion among teachers as to the time when the system should be taught and suggests it may be largely determined by the science work in the school.

DYSON, F. W. A Plea for Astronomy. *The Mathematical Gazette*, VII, No. 113 (October, 1914), 394-398. An address to the London Branch of the Mathematical Association by the Astronomer Royal upon his election as President. The speaker thinks astronomical illustrations can be found which will enforce and perhaps enliven lessons in geometry and trigonometry. It was the clear conception of elementary geometrical principles, which led to the fundamental discoveries of astronomy. The Greek astronomers inferred that the earth was spherical from the fact that its shadows cast on the moon always had a circular edge. Astronomers now have an accurate geometrical knowledge of the present state of the solar system.

BALL, W. W. ROUSE. Newton, *The Mathematical Gazette*, Vol. VII, No. 112 (July, 1914), 349-360. A historical sketch of Isaac Newton from his birth, Christmas Day, 1642, to his death in his 85th year, 1727. The writer tells of his early skill in drawing and constructing clocks, kites, etc. As a lad he made many experiments. For instance, he calculated the velocity of the wind in the great gale of September, 1658, by measuring the length of the jumps he could make with and against the wind, and comparing them with the distance he could jump on a calm day; he also made more than one sundial. Considerable detail concerning his several scientific discoveries is given. His chief researches are recalled and somewhat explained.

BEGINNINGS OF AMERICAN PORCELAIN.

In recent months the Bureau of Standards, of the Department of Commerce, has been conducting experiments for the purpose of determining the utility of American materials for the manufacture of certain articles heretofore imported almost entirely from Europe.

Up to the present time, practically all the porcelain crucibles and dishes used in chemical laboratories throughout the country have been imported from Germany. Two years ago the Clay Products Section of the Bureau undertook to ascertain whether or not American materials were suitable for the manufacture of this porcelain. The investigation developed that clays existed in this country from which such wares could be made and which were equal to the foreign product so far as their resistance to temperature changes is concerned, a quality absolutely essential in this ware, but owing to impurities in the clay the ware was defective in color. Recently, the Clay Products Section has developed a method of purifying the clay, which makes possible the manufacture of ware of good color, a detail important not only in this particular ware but in all white-wares. One concern has taken up the manufacture of chemical porcelain, and while the process is yet somewhat in the experimental stage, it is probable that in a short time all varieties of such ware will be made in this country.

In the manufacture of chemical porcelain and similar products, leadless glazes are the only ones that can be used. For this reason and on account of the poisonous nature of the lead compounds used in making the usual type of white-ware glaze, the Bureau has been conducting an experimental study in the field of leadless glazes.

The use of lead compounds has given rise to wide-spread agitation concerning its deleterious influence upon the health of workmen under conditions permitting careless operation and neglect of ordinary sanitary precautions. A study of American white-ware potteries shows, however, that such conditions do not prevail and that in reality the ill effects due to plumbism are very slight in extent. It can not be denied that there is a potential danger, but white-ware and china glazes, made with lead compounds, may be used under proper conditions and by observing suitable precautions, without any danger to the health of the operatives. On the other hand, wherever leadless glazes can be developed and used, such precautions, which in themselves increase the cost of manufacture, do not have to be taken and every element of risk is thus eliminated to the mutual advantage of both employer and employee. The question, therefore, of lead glazes vs. leadless glazes for china or white-ware becomes one of purely technical and practical interest, involving the factors of working properties, quality of finished product, and cost.

The leadless glazes are not an exact substitute for lead glazes. Both have their peculiarities. However, it is not at all unlikely that the production of American porcelain in the near future will lead toward the production of leadless glazes in a natural way, as with a higher biscuiting fire, that is, the fire used in the first baking of the ware before any glaze is applied, it is not at all improbable that the glost or glaze firing, a second or later baking to harden the glaze, may be raised also. In the production of such articles as chemical porcelain, however, the common American practice must be reversed. Instead of a high biscuit and low glost fire, a low biscuit and high glost heat must be used.

It was found that the best leadless glaze worked out in the Bureau's laboratory could be applied upon the biscuited ware as well as the usual lead glaze, but in firing the temperature range of leadless glaze was

found to be narrower than that of the lead glaze. However, the range is sufficiently wide to take care of variations met with in very uniform firing—a condition, though, which is the exception rather than the rule. Leadless glazes do not flow as readily as those made with lead, and therefore do not cover bare spots as well. For this reason the number of seconds, i. e., defective or second quality articles, is more and the cost of manufacture about 15 per cent greater. Leadless glazes do not seem to have a detrimental effect on the underglaze colors, with the exception of pink. With certain colors they brought about better brilliancy than the lead glazes. They are whiter than the lead but, in the white, somewhat less brilliant.

There is no question but that leadless glazes could be used for a variety of products, especially for architectural terra cotta, tile, enameled brick, etc. With reference to pottery, the leadless glazes do not exactly replace the present lead-boracic acid glazes. There is nothing to prevent the technical application of leadless glazes, even at the present time, but this would require far greater care in burning than is possible with the present type of kilns. The use of glazes, free from lead, would therefore require some radical changes in regard to kiln construction.

The Bureau has worked out a leadless glaze for low temperatures which seems to work better than any other glaze of the same type, which has come to its knowledge.

ISSUES BULLETIN.

The International Commission on the Teaching of Mathematics has recently issued, through the Bureau of Education at Washington, an important bulletin on the teaching of elementary and secondary mathematics in all the leading countries of the world. This bulletin, No. 45, 1914, was prepared by J. C. Brown, and sets forth the nature of the mathematics taught in every school year, from the first through the twelfth, in the standard type of school. It should be in the hands of every teacher of mathematics, and may be secured by addressing the United States Commissioner of Education, Washington, D. C. DAVID EUGENE SMITH.

NOTICE.

TO MEMBERS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS:

The Executive Committee at its May meeting appointed a committee consisting of Messrs. Cobb, Millis, C. H. Smith, Tower, and J. H. Smith, to inquire into the question as to whether too large a part of the annual income has been devoted to the publication of the *Proceedings*. The appointment of the committee is not to be construed as indicating that the policy of the past has been unwise; but in view of the uses in connection with the work of the sections and of the Association for which the funds have been restricted, the question is raised as to whether the *Proceedings* might not be more abridged than in the past, and the money thus saved directed through other channels.

At the next annual meeting the committee is expected to report a recommendation regarding the future policy of the Association. Members of the Association are invited to express their views of the subject in writing addressed to the Chairman of the committee. A prompt response is requested.

JAMES H. SMITH, *Chairman*,
5441 Race Ave., Chicago, Ill.

PLANTS GROWN IN SCHOOLROOM STIMULATE INTEREST IN AGRICULTURE.

Certain Plants Capable of Enduring Adverse Conditions May Be Grown in Separate Pots or in Window Boxes.

Growing plants in the schoolroom will help to stimulate the interest of the young people in agriculture and gardening, according to the U. S. Department of Agriculture's specialist.

The conditions in a schoolroom are, of course, not favorable to plants. Light, heat, and ventilation are very uncertain, particularly during the interim between Friday afternoon and Monday morning. The plants which are capable of enduring such adverse conditions as usually obtain during this period, are few. The following, however, may be mentioned as among those possessing most merit for schoolroom use:

PLANTS SPECIALLY ADAPTED TO SCHOOLROOM CONDITIONS.

Aspidistra lurida; Lantana; begonia; umbrella plant; sword fern; Ficus elastica; oleander; oxalis; German ivy; Peperomia; Aspidistra elatior var. variegata; geranium; cactus; amaryllis; Jerusalem cherry; Abutilon; screw pine (Pandanus); Primula obconica; asparagus sprengeri; Sansevieria zeylanica.

HOW TO MAKE WINDOW BOXES.

If window boxes are used, they must be made comparatively deep and must contain a larger quantity of soil than is commonly necessary for the growth of plants in greenhouses in order that the adverse conditions may in part be counteracted. Boxes intended for window gardens should therefore be made at least six to eight inches in depth, should be rather broad, and of a length to conform to the window opening. The soil should be rich garden loam or a compost consisting of rotted sods and stable manure thoroughly mixed together and screened through a screen with at least a half-inch mesh.

Before filling the box a layer of broken pots, or coarse gravel, or clinkers from the ash heap should be placed over the bottom of the box to the depth of one inch. If the box is made airtight, holes should be provided in the bottom, in order that any excess of moisture which comes from watering the plants may escape from the bottom. After placing this drainage material in the bottom of the box fill it to within one inch of the top with the soil above described. Window boxes which are to be used for propagating plants from cuttings need not be more than six inches deep, and should have the drainage material above mentioned, with about three inches of clean sand placed over the clinkers.

The cuttings may then be prepared as suggested and planted in rows about three inches apart, with the ends of the cuttings inserted about one inch deep in the sand. Thoroughly moisten the sand after placing the cuttings in position, and cover the box for twenty-four hours with an old newspaper. After that time replace the newspaper by panes of glass, which should themselves be shaded by a single sheet of newspaper when the sun is too intense. Remove the shade when the sun does not shine directly on the plants, and if moisture condenses to any considerable extent upon the glass, lift or partly remove the glass so as to give ventilation, but do not allow the cuttings or the sand to become dry.

Plants to be used in window boxes can be grown from seeds sown in 4-inch pots, prepared somewhat as follows: Place a layer of broken pots, gravel, or clinkers in the bottom of the pot, and on top of this fill the pot to within about an inch of the surface with a compost similar to that suggested for filling window boxes. If the seeds to be sown are small and fine, like the begonia, sprinkle a thin layer of sand over the

surface of the soil in the pot and sow the seeds in the sand. Moisten the earth by setting the pot for a minute in a receptacle which contains water of sufficient depth to bring it to within an inch of the surface of the soil in the pot. Lift the pot from the water as soon as the soil is moistened; place it in a warm, sunny situation, and cover it with a piece of glass, As soon as the seeds begin to germinate, remove the glass to a slight extent by placing under one edge a match, or by slipping it partly off the surface of the pot. Judgment must be used in regard to the amount of air to be given to prevent the plants from becoming drawn and yet keep them from being injured by becoming too dry.

Large seeds, like seeds of the nasturtium, should be planted about an inch deep in the soil of the pots, prepared as above described, but no layer of sand need be used with plants of this character.

The character of plants to be used in a box will be determined by the preferences of the cultivator, but in general they should be small and compact in habit of growth, or those which can be trained readily on strings. The following list will serve as a guide in their selection:

Plants which can be grown from seed: Ageratum, petunia, sweet alyssum, mignonette, Lobelia erinus, portulaca, Bellis perennis, Primula obconica, coleus, nasturtium (dwarf), dianthus, stock.

Other plants which can best be propagated by s'ips or cuttings are: Geranium, fuchsia, calla, begonia, Lantana, Abutilon, German ivy, Tradescantia, Vinca.

SCHOOL GARDENS.

There is rapidly coming into vogue in our secondary schools a movement providing that a portion of the grounds around the school building shall possess a school garden of some kind. The writer does not mean by "garden" that the pupils shall be taught to raise nothing but vegetab'es, but the term should be broad enough to include in its meaning the parking and landscaping of the entire grounds and building, making it an attractive place, and securing the means to plant trees, shrubbery, and flowers, choosing those which are best adapted for the locality. These planted in the nooks and corners and open places in and around the grounds will add much to the appearance and value of the school. These gardens should be placed in charge of the instructors of agriculture, botany and zoō'ogy, and should be an important feature in the efficiency of any school that takes up the matter and carries it out to a successful end. The patrons of the school would take kindly to such a proposition, and undoubtedly would lend every aid. The Parent-Teacher's Association should stand back of the movement, and give its support and help to encourage the carrying out of the idea.

The writer wishes to say here in this connection that when Boards of Education are purchasing property for new buildings, they should take into consideration the fact that the building ought to stand in the center of a city block, and contiguous to this should be purchased another block, which should be reserved as a p'ayground for the pupils. The education of the youngster in this day and age must mean all phases of his development, and this development of his physical being appeals to him and is also valuable to him. The inviting grounds and an athletic field will cause much of the tendency which now exists in the minds of some of our boys—that is, to leave high school at the end of the first or second year—to disappear entirely.

SCIENCE QUESTIONS.

By Franklin T. Jones,

University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

189. *Proposed by A. Haven Smith, Riverside, Cal.*

What is the numerical value of the heat of vaporization of water at temperatures other than 100°C.?

190. *Proposed by Mary F. Morris, Newtown H. S., Elmhurst, N. Y., taken from Wentworth's Advanced Arithmetic, p. 374, Ex. 30.*

Find the difference in length at 80° F., of a glass rod and a steel rod, each 3 ft. long at 0°C., if the expansion at 100°C. is 0.00085 for glass and 0.0012 for steel.

Harvard—Physical Science—June, 1887.

(*Continued from the June Number.*)

[*This is one of the earliest published papers in physics given as a college entrance examination.*—Ed.]

[Candidates may omit any question except the first.]

C. 1. Describe fully, but concisely, some experiment upon which you have spent not less than one and a half hours of laboratory work.

191. If a carriage wheel be resting upright upon the ground, and be prevented from slipping at the bottom, how great a force applied horizontally at the top will just neutralize a force equal to the weight of 50 lbs. applied horizontally in the opposite direction at the center of the wheel?

3. Define carefully the *dyne* and *erg*, or the *poundal* and *foot-poundal*.

4. If a body be acted on by a constant force which imparts to it in 1 second a velocity of 1 m. per second, how far will it have moved in 5 seconds, starting from rest?

5. Define *density* and *specific gravity*, distinguishing between the two.

A certain solid floats in water with only two-thirds of its volume submerged, what is the specific gravity of this solid?

192. Into 110 grams of water at 15° C. contained in a vessel the thermal capacity of which is equal to that of 10 grams of water, are put 200 grams of a certain solid at 100° C., and the resulting temperature of the whole is 25° C. Calculate the specific heat of the solid.

7. What is photometry? What difficulties, if any, have you encountered in making experiments in photometry?

8. Describe carefully and fully some galvanic cell you have used.

Solutions and Answers.

177. *From a Williams College examination paper.*
Ans. 5 lb., 20 lb.

178. *From a Williams College examination paper.*
Ans. 36 tons.

179. *From a Williams College examination paper.*
Ans. 9.1 gm. per cc.

180. *From a Williams College examination paper.*
Ans. 4.47 ft.

181. *From a Williams College examination paper.*
Ans. 6.77 gm.

182. *From a Cornell Freshman Chemistry Exam.*
What volume of gas, measured under standard conditions, would be liberated respectively by the action of—(*a*) Hydrochloric acid in excess upon 100 grams of calcium carbonate? (*b*) Sulfuric acid in excess upon 65 gm. of zinc? (*c*) Water in excess upon 128 gm. of calcium carbide? (*d*) Hydrochloric acid in excess upon 88 grams of ferrous sulfid?

Solution by the Editor:

(*a*) $CaCO_3+2HCl \rightarrow CaCl_2+CO_2+H_2O$

100 gm. — *22.4 liters

$\frac{100}{100} = \frac{22.4}{x}$, $x = 22.4$ liters, *Ans.*

(*b*) $Zn+H_2SO_4 \rightarrow ZnSO_4+H_2$

65 gm. — *22.4 liters

65 gm. $x = 22.4$ liters, *Ans.*

(*c*) $CaC_2+2H_2O \rightarrow C_2H_2+Ca(OH)_2$

64 — *22.4 liters

128 gm. $x = 44.8$ liters, *Ans.*

(*d*) $FeS+2HCl \rightarrow FeCl_2+H_2S$

88 — *22.4 liters

88 gm. $x = 22.4$ liters, *Ans.*

*According to Avogadro's hypothesis, *the molecular weight in grams will be contained in 22.4 liters* at standard conditions of temperature and pressure.

183. *From a Cornell chemistry paper.*
What volume of a solution of hydrochloric acid containing 73 gm. of HCl per liter will be required for the complete neutralization of a solution of sodium hydroxide obtained by bringing 23 gm. of metallic sodium into contact with water?

Solution by R. W. Boreman, Parkersburg, W. Va.

23.05
$Na+H_2O = NaOH+H$
23 — 36.458
$NaOH+HCl = NaCl+H_2O$
x

23.05 : 36.458 = 23 : x. $x = 36.38$ gr. Then there would be $\frac{36.38}{73}$ liters or 498 cc. of the acid used.

PROBLEM DEPARTMENT.

By I. L. Winckler,
Central High School, Cleveland, Ohio.

Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and solutions will be credited to their authors. Address all communications to I. L. Winckler, 32 Wymore Ave., E. Cleveland, Ohio.

[Note: Through an error the problems proposed in the April and May issues were numbered the same. The following are the solutions of those proposed in the April number.]

Algebra.

431. *Proposed by the Editor.*

Solve:

$$x^2-(y-z)^2=a^2. \tag{1}$$
$$y^2-(z-x)^2=b^2. \tag{2}$$
$$z^2-(x-y)=c^2 \tag{3}$$

I. *Solution by Elmer Schuyler, Brooklyn, N. Y., and R. M. Mathews, Topaz, Calif.*

The product of (1), (2), (3) gives

$$(x+y-z)^2(x-y+z)^2(-x+y+z)^2=a^2b^2c^2. \tag{4}$$

Taking the square root of (4)

$$(x+y-z)(x-y+z)(-x+y+z)=\pm abc. \tag{5}$$

Dividing (5) by (1), etc.

$$-x+y+z=\pm\frac{abc}{a^2}. \tag{6}$$

$$x-y+z=\pm\frac{abc}{b^2}. \tag{7}$$

$$x+y-z=\pm\frac{abc}{c^2}. \tag{8}$$

From (6), (7), and (8)

$$x=\pm\frac{abc}{2}\left(\frac{1}{b^2}+\frac{1}{c^2}\right),\ y=\pm\frac{abc}{2}\left(\frac{1}{c^2}+\frac{1}{a^2}\right),$$
$$z=\pm\frac{abc}{2}\left(\frac{1}{a^2}+\frac{1}{b^2}\right).$$

II. *Solution by N. P. Pandya, Sojitra, Dt. Petlad, India.*

From (1) $(x-y+z)(x+y-z)=a^2.$ (3)

From (2) $(y-z+x)(y+z-x)=b^2.$ (4)

$\therefore$ by division, $\dfrac{x-y+z}{y+z-x}=\dfrac{a^2}{b^2}$,

$\therefore$ by composition and division, $\dfrac{z}{x-y}=\dfrac{a^2+b^2}{a^2-b^2}$,

$$\therefore (a^2+b^2)x-(a^2+b^2)y-(a^2-b^2)z=0. \tag{5}$$

Similarly $(b^2-c^2)x-(b^2+c^2)y+(b^2+c^2)z=0.$ (6)

$\therefore$ by cross multiplication, $\dfrac{x}{2a^2(b^2+c^2)}=\dfrac{y}{2b^2(c^2+a^2)}=\dfrac{z}{2c^2(a^2+b^2)}$

$=k$ (suppose).

$\therefore x = 2ka^2(b+c^2)$; etc.

Substituting in (1) and simplifying, we get $k = \pm \frac{1}{4abc}$.

$$\therefore x = \pm \frac{a(b^2+c^2)}{2bc}\ ;\ y = \frac{b(c^2+a^2)}{2ca}\ ;\ z = \frac{c(a^2+b^2)}{2ab}.$$

Geometry.

432. *Proposed by W. L. Baughman, East St. Louis, Illinois.*

Given a triangle, altitude h and base b. A square is inscribed in the triangle, one of its sides lying in the base. Find the area of the square in terms of h and b.

I. *Solution by L. E. A. Ling, La Grange, Illinois.*

Put $x =$ to the side of the square.

Then $h : b = h-x : x$,

and $hx = hb-bx$.

$$\therefore x = \frac{hb}{h+b}$$

and $x^2 = \frac{h^2b^2}{(h+b)^2} =$ the area.

II. *Solution by Herbert N. Carleton, West Newbury, Mass.*

Let Δ ABC represent the given triangle, in which the square DEHF is so inscribed that the side FH lies in the base BC of the given triangle.

Draw AK $\perp$ to BC, intersecting DE at J.

Let $x =$ side of square.

$$AJ = AK-JK = AK-DF = h-x.$$

Area square DEHF $= x^2$.

Area Δ ADE $= \frac{1}{2} \cdot DE \cdot AJ = \frac{1}{2}x \cdot (h-x) = \frac{1}{2}(hx-x^2)$.

Area Δ DBF $+ \Delta$ EHC $=$ area of a Δ whose base is BF+HC or BC—FH or $b-x$, and whose altitude is DF $=$ EH $= x$.

$\therefore$ Area Δ DBF $+ \Delta$ EHC $= \frac{1}{2}x \cdot (b-x) = \frac{1}{2}(bx-x^2)$.

Area Δ ABC $=$ area square DEHF $+$ area Δ ADE $+$ area (Δ DBF $+ \Delta$ EHC)

$$= x^2+\tfrac{1}{2}(hx-x^2)+\tfrac{1}{2}(bx-x^2) = \tfrac{1}{2}(2x^2+hx-x^2+bx-x^2)$$
$$= \tfrac{1}{2}(hx+bx).$$

But area Δ ABC $= \frac{1}{2}bh$.

$\therefore \frac{1}{2}(hx+bx) = \frac{1}{2}bh$, or,... $hx+bx = bh$, or,... $(h+b)x = bh$.

$\therefore x = \frac{bh}{b+h}$. Area of inscribed square $= x^2 = \left(\frac{bh}{b+h}\right)^2$.

433. *Proposed by Nelson L. Roray, Metuchen, New Jersey.*

A polygon of $2n$ sides is inscribed in a circle. There are n sides each equal to a and n sides each equal to b. Find the radius of the circle.

I. *Solution by R. M. Mathews, Topaz, California.*

Let V be a vertex where an a-side, AV, and a b-side, BV, meet. Let α and β be the central angles subtended by a and b respectively. Now since

$$n\alpha+n\beta = 2\pi$$

$$\frac{\alpha+\beta}{2} = \frac{\pi}{n}$$

Further $$\angle AVB = \pi - \frac{\alpha+\beta}{2} = \frac{n-1}{n}\pi.$$

If r be the radius of the circle,

$$AB = 2r \sin\frac{\alpha+\beta}{2},$$

$$\text{also } \overline{AB}^2 = a^2+b^2+2ab\cos\frac{\alpha+\beta}{2}.$$

$$\therefore \quad 4r^2\sin^2\frac{\pi}{n} = a^2+b^2+2ab\cos\frac{\pi}{n}$$

whence
$$r = \frac{\sqrt{a^2+b^2+2ab\cos\frac{\pi}{n}}}{2\sin\frac{\pi}{n}}.$$

II. *Solution by Mabel G. Burdick, Stapleton, New York.*

Let two sides a and b be adjacent, the central angles corresponding be α and β respectively, and the chord subtending the angle $(\alpha+\beta)$ be c; also the radius be R.

In the triangle abc,

$$c = \sqrt{a^2+b^2-2ab\cos\left(180-\frac{\alpha+\beta}{2}\right)}.$$

In the triangle formed by c and two radii,

$$\frac{R}{c} = \frac{\sin\left(90-\frac{\alpha+\beta}{2}\right)}{\sin(\alpha+\beta)} = \frac{\cos\frac{\alpha+\beta}{2}}{2\sin\frac{\alpha+\beta}{2}\cos\frac{\alpha+\beta}{2}} = \frac{1}{2\sin\frac{\alpha+\beta}{2}}, \quad \alpha+\beta = \frac{360}{n}.$$

$$\cos\left(180-\frac{\alpha+\beta}{2}\right) = \cos\left(180-\frac{180}{n}\right) = -\cos\frac{180}{n}.$$

Solving for R and substituting

$$R = \frac{\sqrt{a^2+b^2+2ab\cos\frac{180}{n}}}{2\sin\frac{180}{n}}.$$

434. *Proposed by Daniel Kreth, Wellman, Iowa.*

From a point without a square the distances to the three nearest vertices of the square are 20, 30, and 40. Find the side of the square.

I. *Solution by Norman Anning, Clayburn, B. C.*

Suppose the square, whose side a is to be found, is placed in the first quadrant with two sides coinciding with the axes. Let $(-x, -y)$ be the coördinates of the point whose distances from the nearest vertices are 2 tens, 3 tens and 4 tens.

$$x^2+y^2 = 4.$$
$$x^2+(a+y)^2 = 9.$$
$$y^2+(a+x)^2 = 16.$$
$$a^2+2ay = 5.$$
$$a^2+2ax = 12.$$
$$4 = x^2+y^2 = \left(\frac{5-a^2}{2a}\right)^2+\left(\frac{12-a^2}{2a}\right)^2.$$
$$2a^4-50a^2+169 = 0.$$
$$a^2 = \frac{25\pm\sqrt{287}}{2}.$$
$$a = 4{\cdot}57936,\ 2{\cdot}00735 \text{ tens}$$

$= 45{\cdot}7936,\ 20{\cdot}0735.$

Only the smaller value is consistent with the data, the other is for a point "within."

II. *Solution by Elmer Schuyler, Brooklyn, New York.*

Let $x =$ the side of the square and ϕ be the angle between the lines x and 20.

Then $$400+x^2-40x\cos\phi = 900,$$

and $$400+x^2+40x\sin\phi = 1600.$$

Eliminating sin ϕ and cos ϕ we obtain

$$x^4-2500x^2 = 717500.$$

$$\therefore x = 20.073 \text{ or } 45.793.$$

It can easily be shown that the point must be inside the square for $x = 45.793$ and outside for $x = 20.073$.

III. *Solution by W. T. Harlow, Portland, Oregon.*

Let ABCD be the square; P, the point outside. Draw PL parallel to AD meeting CD produced; PN parallel to AB meeting CB produced. Draw AK perpendicular to PL and AM perpendicular to PN. Let $u =$ PK; $v =$ PM; $w =$ PL; $s =$ PN. Join PD, PA, PB. Solve on a scale of one-tenth when these distances become 4, 2, and 3, respectively. $x =$ side.

In triangle PLD, $$w^2+v^2 = 16.$$

In triangle PKA, $$u^2+v^2 = 4.$$

$$\therefore w^2-u^2 = 12.$$

Since $w-u = x$, $$w+u = 12/x.$$

Subtracting $$w-u = x.$$

$$u = \frac{12-x^2}{2x}.$$

In triangle PNB, $$s^2+u^2 = 9.$$

$$u^2+v^2 = 4.$$

$$s^2-v^2 = 5.$$

Since $s-v = x$, $$s+v = 5/x.$$

Subtracting $$s-v = x.$$

$$v = \frac{5-x^2}{2x}.$$

Since $u^2+v^2 = 4$, $$\left(\frac{12-x^2}{2x}\right)^2+\left(\frac{5-x^2}{2x}\right)^2 = 4,$$

whence $x^4-25x^2 = -84.5$, $\quad x = 2.0073+$

and the required side is 20.073+ ft.

IV. *Solution by Herbert N. Carleton, West Newbury, Mass.*

Let ABCD be the given square and P the given point. Then PA = 20, PB = 30, PD = 40. Draw the diagonal BD. Through P draw a line parallel to BA, meeting DA produced at E. Let $x =$ side of square. The triangles PAB and ABD have a common base AB. Then the area of $\triangle$ ABD $= \frac{1}{2}x^2$ and its altitude AD $= x$.

$$\tfrac{1}{2}(AB+PA+PB) = \frac{x+50}{2} = \text{half the perimeter of } \triangle PAB.$$

$$\text{Area of } \triangle PAB = \sqrt{\left(\frac{x+50}{2}\right)\left(\frac{x+50}{2}-x\right)\left(\frac{x+50}{2}-20\right)\left(\frac{x+50}{2}-30\right)}$$

$$= \sqrt{\left(\frac{50+x}{2}\right)\left(\frac{50-x}{2}\right)\left(\frac{x+10}{2}\right)\left(\frac{x-10}{2}\right)} = \sqrt{\frac{(50+x)(50-x)(x+10)(x-10)}{16}}$$

$$= \tfrac{1}{4}\sqrt{(50^2-x^2)(x^2-10^2)} = \tfrac{1}{4}\sqrt{2600x^2-x^4-500^2}.$$

The triangles PAB and ABD having the same base AB, their areas are to each other in the same ratio as their altitudes AE and AD.

$\therefore \frac{1}{2}x^2 : \frac{1}{4}\sqrt{2600x^2-x^4-500^2} = x : \text{AE}.$

$\therefore \text{AE} = (x \cdot \frac{1}{4}\sqrt{2600x^2-x^4-500^2}) \div \frac{1}{2}x^2 = \frac{1}{2x} \cdot \sqrt{2600x^2-x^4-500^2}.$

$\text{ED} = \text{AD}+\text{AE} = x+\frac{1}{2x}\sqrt{2600x^2-x^4-500^2}.$

$\text{EP} = \sqrt{(\text{PA})^2-(\text{AE})^2}$. Also, $\text{EP} = \sqrt{(\text{PD})^2-(\text{ED})^2}$.

$\therefore \sqrt{(\text{PA})^2-(\text{AE})^2} = \sqrt{(\text{PD})^2-(\text{ED})^2}$

In this last equation, substitute the given values of PA and PD, and the ascertained values of AE and ED in terms of x.

Then $\sqrt{(20)^2-\left(\frac{1}{2x}\sqrt{2600x^2-x^4-(500)^2}\right)^2}$

$$= \sqrt{(40)^2-\left(x+\frac{1}{2x}\sqrt{2600x^2-x^4-(500)^2}\right)^2}$$

Squaring the above equation, we obtain

$$400-\frac{1}{4x^2}(2600x^2-x^4-500^2) = 1600-$$

$$\left[x^2+\sqrt{2600x^2-x^4-500^2}+\frac{1}{4x^2}(2600x^2-x^4-500^2)\right].$$

Removing parentheses, omitting terms common to both members, transposing and reducing, we obtain, $1200-x^2-\sqrt{2600x^2-x^4-500^2} = 0$.

$\therefore x^4-2500x^2 = -845000$, and

$x = 45.793599$ or 20.0735219.

But the *first* value is *inadmissible*, since for any point *without the square*, at least *one* of the three distances from the vertices must be $>$ side of square.

Ans. 20.0735219.

435. *Problem 435 in geometric form and generalized.—Editor.*

To construct a triangle similar to a given triangle and having its three vertices on the circumferences of three given concentric circles.

I. *Solution by James H. Weaver, West Chester, Pa.*

Let ABC be the given triangle, and let O be the center of three concentric circles whose radii are proportional to the radii of the given circles and which contain the vertices A, B and C. Let $\text{AC} = b$.

Then the locus of points that are at distances from A and C in the ratio of $r_2 : r_1$ is represented by the equation

$$\left(x-\frac{r_2^2 b}{r_2^2-r_1^2}\right)^2+y^2 = \left(\frac{r_1 r_2 b}{r_2^2-r_1^2}\right)^2$$

where A is origin, AC is x-axis.

The center of this circle is given by

$\frac{r_2^2 b}{r_2^2-r_1^2} = \text{C}_1$ (C_1 can be constructed geometrically by two fourth proportional constructions),

measured from A along AC or AC produced. Also the radius of the circle is $\frac{r_1 r_2 b}{r_2^2 r_1^2} = \text{D}_1$ (D_1 can be constructed in the same way as C_1).

In the same way find the locus of points that are at distances from C and B in the ratio $r_1 : r_2$ and find the center and radius of this circle as in the one just described. Then the points of intersection of these two circles will establish centers from each of which as O, circles drawn passing

through A, B, C will have radii proportional to the given radii. Then in the given circles construct at O′ angles equal to the angles at O, arranging the radii in the same order as at O. Then where the radii cut their respective circumferences will be the vertices of the required triangle, because the two figures at O and O′ will be similar in every respect. There will in general be 12 solutions.

II. *Solution by Norman Anning, Clayburn, B. C.*

Given the distances from a fixed center O, OA, OB, OC $= p$, q, r respectively, to construct the triangle ABC having given angles A, B and C.

The angles AOB, BOC, COA. are connected by the relation.

$$\cos^2 AOB+\cos^2 BOC+\cos^2 COA = 1+2\cos AOB \cos BOC \cos COA.$$

Now $\cos AOB = \dfrac{p^2+q^2-c^2}{2pq}$, etc.

Putting in these values of the cosines we get the relation connecting the six distances of any four points in the plane which is expressed shortly by the determinant,

$$\begin{vmatrix} 0 & 1 & 1 & 1 & 1 \\ 1 & 0 & p^2 & q^2 & r^2 \\ 1 & p^2 & 0 & c^2 & b^2 \\ 1 & q^2 & c^2 & 0 & a^2 \\ 1 & r^2 & b^2 & a^2 & 0 \end{vmatrix} = 0.$$

In expanded form,

$$\begin{aligned} a^2b^2c^2-a^2p^2(b^2+c^2-a^2)-b^2q^2(c^2+a^2-b^2)-c^2r^2(a^2+b^2-c^2) \\ +a^2(p^4-p^2q^2-p^2r^2+q^2r^2) \\ +b^2(q^4-q^2r^2-q^2p^2+r^2p^2) \\ +c^2(r^4-r^2p^2-r^2q^2+p^2q^2) = 0. \end{aligned}$$

Using the relations,

$$b^2+c^2-a^2 = 2bc\cos A, \text{ etc.}$$
$$a = 2R\sin A, \text{ etc.}$$
$$\Delta = 2R^2 \sin A \sin B \sin C;$$

this reduces to

$$4\Delta^2-2\Delta\ (\Sigma p^2 \sin 2A)+[\Sigma(p^2-q^2)\ (p^2-r^2)\sin^2 A] = 0.$$

a quadratic in Δ.

Solve the quadratic for Δ, find a from

$$\Delta = \frac{a^2 \sin B \sin C}{2 \sin A}$$

and construct the triangle.

This solution is not geometrical save in the sense that it contains only equations whose solutions can be constructed with straight-edge and compasses. It is, however, general and yields a solution whenever there is one while, I think, the method of pure geometry is not available for cases like

$$p+q<r.$$

429. *Proposed by N. P. Pandya, Sojitra, Dt. Petlad, India.*

[No solution of this problem had been received in time for the June number.]

Construct a triangle ABC, A being the point of contact of two given circles having an internal contact, BC a chord of the larger circle tangent to the smaller, and having given AB : AC $= m : n$.

I. *Solution by the Proposer.*

Let r_1 and r_2 be the radii of the larger and smaller circles, respectively. Let O be the centre of the larger circle.

Take $$p = \frac{r_2(m+n)^2}{2mn} - r_1.$$

Describe a circle with centre O and radius p. Draw a direct common tangent to the smaller circle and the third circle, the points of contact being E and D, respectively. Let it cut the larger circle at B and C. Then ABC is the required triangle. DE is a direct common tangent to circles whose radii are r_2 and p and whose centres are r_1-r_2 units apart.

$$\therefore \overline{DE}^2 = (r_1-r_2)^2-(r_2-p)^2 = (r_1-p)\ (r_1+p-2r_2)$$

$$\text{and } \overline{BD}^2 = \overline{BO}^2-\overline{OD}^2 = r_1^2-p^2 = (r_1-p)\ (r_1+p).$$

$$\therefore \overline{DE}^2 : \overline{BD}^2 = (r_1+p-2r_2)\ : (r_1+p)$$

$$= \frac{r_2(m-n)^2}{2mn} : \frac{r_2(m+n)^2}{2mn}$$

$$= (m-n)^2 : (m+n)^2.$$

$$\therefore DE : BD = m-n : m+n.$$

$$\therefore BE : EC = m : n.$$

Now if PAQ be the tangent at A, and if AB, AC intersect the smaller given circle at H and K,

$$\angle BAE = \angle PAE-\angle PAB = \angle AKE-\angle ACB = \angle KEC = \angle EAC.$$

$$\therefore AE \text{ bisects the angle } BAC.$$

$$\therefore AB : AC = BE : EC = m : n.$$

II. *Solution by F. C. Asbury, Toronto, Canada.*

Analysis: Let r be radius of inner circle, with centre at O; R, radius of outer circle.

Suppose ABC, the required Δ; $\dfrac{AB}{AC} = \dfrac{m}{n}$.

BC touches, and AB and AC cut the inner circle at D, E and F, respectively.

Join AD, DE, DF.

Draw $AG \perp BC$ and $DH \perp AC$.

At A draw the common tangent XAY, meeting CB produced at X. Also produce CA to T, making $AT = AB$.

(1) AD bisects $\angle BAC$; for,

$$\angle BAD = \angle XAD-\angle XAB = \angle XDA-\angle BCA = \angle DAC.$$

(2) $\angle BDA = \angle DFA$. Hence right triangles AGD, DHF are similar.

Now $AD \cdot DF = 2r \cdot DH$ and $AB \cdot AC = 2R \cdot AG$.

$$\therefore \frac{AD \cdot DF}{AB \cdot AC} = \frac{2r \cdot DH}{2R \cdot AG} = \frac{r}{R} \cdot \frac{DH}{AG} = \frac{r}{R} \cdot \frac{DF}{AD}.$$

$$\therefore \overline{AD}^2 = \frac{r}{R}(AB \cdot AC).$$

(3) Now, since AD bisects $\angle BAC$

(*a*) $$\frac{AB}{AC} = \frac{BD}{DC} = \frac{m}{n}$$

(*b*) $$AB \cdot AC = BD \cdot DC+\overline{AD}^2 = BD \cdot DC+\frac{r}{R}(AB \cdot AC)$$

$$\therefore \frac{AB \cdot AC}{BD \cdot DC} = \frac{R}{R-r} \qquad \therefore \frac{AB}{BD} = \frac{AC}{DC} = \sqrt{\frac{R}{R-r}} = K, \text{ say}$$

(determinable).

(4) $$K = \frac{AB}{BD} = \frac{AC}{DC} = \frac{AB+AC}{BC} = \frac{TC}{BC}.$$

It is evident also that

$$\frac{TC}{AB} = \frac{m+n}{m}$$

and

$$\frac{TC}{AC} = \frac{m+n}{n}$$

Hence

$$TC = \frac{AB}{\frac{m}{m+n}} = \frac{BC}{\frac{1}{K}} = \frac{AC}{\frac{n}{m+n}}.$$

Hence the following construction:

Construct any Δ A'B'C' with sides proportional to

$$m, (m+m)\sqrt{\frac{R-r}{R}}, n$$

and obtain thus the angle C' opposite the side m. At the point A in the original figure draw the common tangent XAY. Construct $\angle XAB = \angle C'$ and let the arm of the angle cut the outer circle at B. Draw BD tangent to the inner circle and produce to cut outer circle at C. Join AC.

Then ABC is the required Δ.

Proof: BC has been drawn tangent to inner circle.

It remains to show that $\frac{AB}{AC} = \frac{m}{n}$.

(Additional construction and lettering as in figure of the analysis.)

As before, we have,

(1) AD bisects the $\angle BAC$.

(2) $\overline{AD}^2 = \frac{r}{R}(AB \cdot AC)$.

Also (3) (*a*) $\frac{AB}{AC} = \frac{BD}{DC}$.

(*b*) $\frac{AB}{BD} = \frac{AC}{DC} = K = \sqrt{\frac{R}{R-r}}$.

In the auxiliary Δ A'B'C', bisect $\angle B'A'C'$ by A'D' meeting B'C' in D'. Then

$$\frac{A'B'}{A'C'} = \frac{B'D'}{D'C'} = \frac{m}{n}.$$

$$\therefore \quad \frac{D'C'}{B'C'} = \frac{m}{m+n}.$$

$$\therefore \quad \frac{D'C'}{A'C'} = \frac{D'C'}{B'C'} \cdot \frac{B'C'}{A'C'} = \frac{n}{m+n} \cdot \frac{(m+n)\sqrt{\frac{R-r}{R}}}{n} = \sqrt{\frac{R-r}{R}}.$$

Hence in Δ's A'D'C', ADC we have

$$\frac{D'C'}{A'C'} = \frac{DC}{AC} = \sqrt{\frac{R-r}{R}}$$

and $\angle B'C'A' = \angle BCA$, by construction.

$\therefore$ Δ's A'D'C' and ADC are similar

and $\angle D'A'C' = \angle DAC$.

$\therefore$ $\angle B'A'C' = BAC$.

$\therefore$ Δ's B'A'C' and BAC are similar

and $\frac{AB}{AC} = \frac{m}{n}$.

CREDIT FOR SOLUTIONS.

405. Herbert N. Carleton. (1)

426. N. P. Pandya, Yeh Chi Sun. (2)

427. N. P. Pandya. (1)

428. T. Amaheislman, N. P. Pandya, Yeh Chi Sun. (3)

429. F. C. Asbury, N. P. Pandya. (2)

430. Herbert N. Carleton, N. P. Pandya, Yeh Chi Sun. (3)

431. Norman Anning, A. Babbitt, James A. Bell, Grace Boyd, Walter C. Eells, J. A. Hassler, R. M. Mathews, N. P. Pandya, J. Martin Ryle, Elmer Schuyler, Yeh Chi Sun, H. G. Walters, F. Herbert Wharton, Henry S. Williams. (14)

432. Norman Anning, James A. Bell, Grace Boyd, Mabel G. Burdick, Herbert N. Carleton, J. A. Hassler, L. E. A. Ling, R. T. McGregor, R. M. Mathews, Louis Miller, Leland S. Mills, R. F. Palmer, N. P. Pandya, Elmer Schuyler, Yeh Chi Sun, Clyde H. Wady, H. G. Walters, one incorrect solution. (18)

433. Norman Anning, Mabel G. Burdick, R. N. Mathews, N. P. Pandya, Elmer Schuyler, Yeh Chi Sun. (6)

434. Norman Anning, Herbert N. Carleton, Walter C. Eells, W. T. Harlow, N. P. Pandya, Elmer Schuyler, Yeh Chi Sun, H. G. Walters. (8)

435. Norman Anning, James H. Weaver. (2)

Total number of solutions, 60.

PROBLEMS FOR SOLUTION.

Algebra.

441. *Proposed by Herbert N. Carleton, West Newbury, Mass.*

A man can row y miles per hour on a certain river with the current in his favor, but only x miles per hour against the current. The numbers x and y are such that $x = \sqrt[x]{y} = y^{\frac{x}{y}}$. Starting from point A, rowing down stream as far as point B, and returning to his starting point, rowing continuously at the constant rates above specified, he makes the round trip in $7\frac{1}{2}$ hours. Find the distance AB, numerically expressed.

Geometry.

442. *Proposed by Mabel G. Burdick, Stapleton, New York.*

The locus of points whose distances from two fixed points have a given ratio $(m:n)$ is the circumference of a circle whose diameter divides the line joining the fixed points harmonically in the given ratio.

Prove:

I. That any point in the circumference satisfies the given condition.

II. That any point satisfying the given condition lies in the circumference.

443. *Proposed by Norman Anning, Clayburn, B. C.*

Triangle ABC is right angled at A. AD is perpendicular to BC and E is a point in BC such that CE = CA. Show that

$$\frac{1}{ED} = \frac{1}{EB} + \frac{1}{EC}.$$

444. *Proposed by A. Heinz, Cameron, Mo.*

The following construction is given without proof in a Chinese book of Constructions:

To construct a regular pentagon on AB as a side.

(1) With A and B as centers and AB as radius, draw circles intersecting at C and D.

(2) With C as centre and radius CA, draw a circle cutting circles A and B at E and F, respectively, and CD at G.

(3) Join EG and FG, produce to meet circles B and A at H and I, respectively.

(4) With H and I as centres and radius AB, draw arcs cutting at J on CD produced.

(5) ABHJIA is the required pentagon.

Prove this construction correct or incorrect—a geometric proof desired.

Trigonometry.

445. *Proposed by Nelson L. Roray, Metuchen, New Jersey.*

If the bisectors of angles B and C of a triangle intersect the opposite sides in E and F, respectively, prove that EF makes with BC an angle

$$\tan^{-1}\frac{(b-c)\sin A}{(a+b)\cos C+(a+c)\cos B}.$$

STORIES.

Question: Give the story of the invention of the barometer (told in Carhart & Chute *High School Physics*).

Answers: "Galileo discovered the barometer once when the water would not raise from a well."

"Invented by descending into a deep well, Torricelli."

"Duke of Tuskney wanted to know why he could not pump water out of his well so Toricelio invented the barometer."

A freshman girl in a college not far from Chicago recently informed her instructor that "Eugenics is the science that teaches us that only the best should be allowed to profligate."

If there is anyone who can beat this, send it along. Some years ago, a so-called instructor in zoölogy, on visiting the Biological Department of the University of Chicago, asked the person who was conducting him through the buildings, "if he would kindly allow him to see the University's specimen of a permanently mounted rotating protoplasm."

"SCIENTIFIC" ANSWERS.

By A. L. Jordan,

Polytechnic High School, San Francisco, Cal.

Student (wants billiard ball): "May I have the croquet ball?"

Teacher: "You mean the game where you poke the ball with a cue, thus."

Student: "Oh yes, you mean poker."

Q.: What pressure required to compress air one-half its vol.?

A.: One hemisphere.

"The electric bell has a flopper areture, another kind has a permant magnate instead of an electric magnate."

Name the magnetic substances.

A.: Lodestone, iron, steel, cobalt, and alimony.

PERSONAL.

Professor R. D. Carmichael, who for several years has been Professor of Mathematics at the Indiana State University, Bloomington, has accepted a call to the University of Illinois as Assistant Professor of Mathematics. He begins his work in the new position this fall.

BOOKS RECEIVED.

New Plane Geometry, by Edward R. Robbins, formerly of the Lawrenceville School. Pages viii+264. 14×21 cm. Cloth. 1915. American Book Co., Chicago.

Lectures on Electrical Apparatus and Experiments, Illustrated with Cuts from Lantern Slides, Monograph B-5, for the Physics Teacher. 103 pages. 15×22 cm. Paper. 1915. Western Electrical Instrument Co., Newark, N. J.

Notebook and Laboratory Manual, by John G. Coulter. Loose leaf. 145 pages. 19×24 cm. 1915. American Book Co.

A Brief Laboratory Course in Physical Geography, by L. L. Everly, Normal School, St. Paul, Minn., Ralph E. Blunt and Calvin L. Watson, Chicago High Schools. Loose leaf. 90 pages. 19×24 cm. 1915. American Book Co.

Laboratory Exercises in General Chemistry, by R. H. Williams, Horace Mann School, Teachers College, Columbia University, and W. G. Wittman, Normal School, Salem, Mass. Loose leaf. 161 pages. 19×24 cm. 1915. American Book Co.

Tables and Formuli, by Wm. R. Longley, Yale University. Pages v+37. 12.5×19 cm. Cloth. 1915. 50 cents. Ginn & Co., Boston.

Manual of Weeds, by Ada Georgia, of Cornell University. Pages xi+593. 12.5×19 cm. 1914. $2.00. Macmillan Co.

Methods in Plant Histology, by Charles J. Chamberlain. Pages xi+314. 15×22 cm. 1915. $2.25. University of Chicago Press.

The Carnegie Foundation for the Advancement of Teaching. Ninth Annual Report of the President and of the Treasurer. Pages vi+154. 18.5×25.5 cm. Paper. 1914. 576 Fifth Ave., New York City.

Zoölogy a Textbook for Universities, Colleges and Normal Schools, by Thomas W. Galloway, James Millikan University. Pages xiii+546. 16×23 cm. Cloth. 1915. P. Blakiston's Son & Co., Philadelphia.

Algebra, von Dr. Eugen Netto, Universität Giessen. Pages xii+232. 16×23.5 cm. Cloth. 1915. M7.20. B. G. Teubner, Leipzig.

Didaktik des Physikalischen Unterrichts, von Dr. Friedrich Poske, Berlin. Pages x+428. 16.5×24 cm. Cloth. 1915. M.12. B. G. Teubner, Leipzig.

Repertorium der Physik, Herausgegeben von Rudolph H. Weber, Rostock, und Richard Gans, La Plata Pages xii+434 13×20 cm. Cloth. 1915. M. 8. B. G. Teubner, Leipzig.

Grose Geographen. Bilder aus der Geschichte der Erdkunde, von Prof. Dr. Felix Lampe. 288 pages. 13.5x20 cm. Cloth. 1915. M. 4. B. G. Teubner, Leipzig.

Physikalische Ubungen, Ein Leitfaden für Die Hand des Schulers, von Walther Masche, Berlin. 51 pages. 14.5x22 cm. Paper. 1915. M. 8. B. G. Teubner, Leipzig.

Allgemeine Biologie. Redaktion: C. Chun und W. Johannsen Unter Mitwirkung von A. Gunthart. Pages xi+691. 18×26 cm. Cloth. 1915. M. 23. B. G. Teubner, Leipzig.

Practical Applied Mathematics, by Joseph W. Hale, Pennsylvania State

College. Pages xi+206. 12.5x18 cm. Cloth. 1915. $1.00 net. McGraw-Hill Book Co., New York City.

The Best Private Schools in the United States and Canada. Pages xxiv +514. 12x18.5 cm. Cloth. 1915. $2.00. Porter E. Sargent, 50 Congress St., Boston, Mass.

BOOK REVIEWS.

The Best Private Schools of the United States and Canada. Pages xxiv+514. 12x18.5 cm. Cloth. 1915. $2.00. Porter E. Sargent, 50 Congress St., Boston, Mass.

What a splendid book this is! It is one that all school men who are progressive and inclined toward the administrative end of school matters should possess. People connected with our school system shou'd not only be perfectly familiar with the particular system and school in which they are working, but they should be broad enough to have a good general and working knowledge of the school systems the country over. Then, too, this book is one which should be possessed by parents who are contemplating sending their children to some private school either near at home or at some considerable distance away. From this book they will be able to determine the high points concerning any private school in the country, and they can thereby make an intelligent selection of a school for their children.

There is a short historical sketch of the private school system of the country, with a list and description of the early boys' schools. A description of various boys' schools in New England follows. Then comes a list of boys' schools in the middle states and Maryland, and boys' schools in the various parts of the country fol'ow. In much the same manner and order follow descriptions of schools for girls. Then there are lists of schools of expression and household art, etc. The private schools of Canada are also named and described. Likewise, the schools of the summer camp require several pages for enumeration. Then there are about 140 pages given to comparative tables of the various private schools of both sexes in this country and Canada. In these tables are found the name and location of the school, along with its class, the name of its head, tuition, etc., a valuable feature. Then there is a directory of educational associations and also of some of the leading educational periodicals. Schoolbook publishers and teachers' agencies are also listed. A complete index is given. In fact, it is a most valuable compendium for people of all classes who are interested in private schools. It is published annually. School men should send for a copy. C. H. S.

The Carnegie Foundation for the Advancement of Teaching. Ninth Annual Report of the President, and of the Treasurer. Pages vi+154. 18.5x25.5 cm. Paper. 1914. 576 Fifth Ave., New York, N. Y.

This report, which has recently come from the press, gives very concisely the nature and character of the work which this Foundation has been doing for the year ending Sept. 30, 1914. The financial end of it is interesting, as it shows how the various moneys are invested and how the income has been expended.

The division of "Educational Inquiry" is presented under three heads. There has been a study of the "Legal Education" in the country under the direction of Prof. Josef Redlich of the University of Vienna. This is an interesting and valuable report. "Engineering Education" also has come in for an investigation. Then, too, a very valuable report concerning the study in the state of Vermont is discussed. The report also presents discussions from various state Education Surveys, and summarizes its investigations in this volume, which is of the greatest value to anyone interested in the educational development of the country. The report states that Prof.

C. R. Mann of the Department of Physics of the University of Chicago is spending a year with the Foundation in the Department of Engineering Education. Science men the country over are looking with much interest for the report of Dr. Mann's investigations. C. H. S.

Lectures on Electrical Apparatus and Experiments, Illustrated With Cuts from Lantern Slides, Monograph B-5, for the Physics Teacher. 103 pages. 15x22 cm. Paper. 1915. Weston Electrical Instrument Co., Newark, N. J.

This splendid monograph, which came from the press in May, will surely be received with much interest and enthusiasm by all progressive physics teachers. The book first gives a historical reproduction of the development of electrical science, giving a foundation for a description of the way in which the Weston instruments have been developed, and how they are at present made. In the book are many splendid cuts, some being reproductions of very early experiments, others being half-tones showing how the Weston people construct their instruments, and others being plans of the connection for various e'ectrical experiments. Fourteen excellent experiments are given on practical electrical work, which should be carried out in every up-to-date physics laboratory. These experiments have been worked out by several progressive physics teachers, and they embody the results of these teachers' experience, so that any other instructor in presenting the experiments to his classes will know that they are experiments which will work and produce results. Of course, the Weston instruments are used in all of them. Send for a copy of the monograph. It doubtless will have a wide circu'ation C. H. S.

Elementary Algebra, Complete, Shorter Course, by W. H. Williams, Head of Department of Mathematics, Normal School, Platteville, Wis., and W. B. Kempthorne, Instructor in Mathematics, University of Oregon, Eugene, Oregon. Pages vi+481. 14x19.5 cm. 1914. Lyon & Carnahan, Chicago.

The main features emphasized by the authors are—(1) to correlate the work closely with arithmetic; (2) to introduce but one new difficulty at a time; (3) to emphasize the equation; (4) to lay stress on mental work; (5) to give a large proportion of simp'e exercises; and (6) to emphasize algebraic language. The lists of review exercises at the close of chapters are of advantage in clearing up difficulties. In addition to the usual drill exercises, there is a large number of problems based on geometry, physics, statistics, geographical facts and affairs of daily life. The large-sized type and open spacing make the book attractive. H. E. C.

"Alaskan Glacier Studies of the National Geographic Society in Yakutat Bay, Prince William Sound and Lower Copper River Regions" by Ralph Stockman Tarr and Lawrence Martin. Based upon the field work in 1909, 1910, 1911, and 1913 by National Geographic Society Expeditions. Published by the society at Washington, 1914, xxvii+498 pp. 184 plates. 72 text illustrations, and nine colored maps.

This large and handsome book includes a short introductory section on the distribution of Alaskan glaciers of the past and present, a group of chapters on glaciation near Yakutat Bay, and a group on glaciation in the Prince William Sound and Lower Copper River country. Although some of its contents are familiar to those who have read preliminary papers by the two authors, and although descriptions and illustrations have been freely borrowed from such earlier works as those of Russell and Gilbert, the completeness of this book and the presence in it of new material, make it indispensable to the student of glaciers and glaciation. The authors disclaim any attempt to deal exhaustively with Alaskan glaciers or even with those of the two districts which they selected for

special study; yet there is such a wealth of information concerning the location, appearance, and behavior of these glaciers during the score of years, more or less, in which they have been under observation, that a reader who undertakes to read continuously from cover to cover may become discouraged. The book is primarily a book of reference. As its title suggests, it lacks unity; it is a full reprt of progress rather than a final treatise on the subject of glaciers in Alaska. While it does not invite one to full and continuous reading, the book abounds in interesting descriptions and deductions; and certain chapters, such as those which deal collectively with the glaciers of the respective districts and one which discusses at length the question of the extent to which earthquakes have influenced the rate of advance of glaciers are in themselves of absorbing interest.

The opening chapter consists of a catalog, in geographic order, of those glaciers which have been mentioned in reports. While there are several hundred of these, the authors point out that many thousands must exist, inasmuch as only those which are easily accessible from the coast have been explored, and even these are unknown in their upper reaches. The remarkable development of glaciers on the Pacific coast of Alaska is attributed to the presence of the St. Elias and other ranges, which force the moist west winds to rise and cool causing heavy precipitation. At the seacoast the rainfall amounts to from 60 to 190 inches annually; on the mountains the amount of snowfall is also extreme, although not equally phenomenal. On the sheltered eastern side of the ranges glaciers are comparatively few and small. Those on the seaward side, however, rank next in size to the glaciers of polar regions. The Hubbard glacier, for instance, with a known length of 28 miles and a probable length along unexplored tributaries of 40, has a trunk stream of which the terminal portion alone is sufficient to cover the Aletsch, Rhone, and Mer de Glace. It is evident, therefore, that for a study of living glaciers Alaska affords exceptional opportunity.

Tarr's chapters on the glaciers and glaciation of Yakutat Bay are both descriptive and philosophical. Importance is attached to the great Malaspina glacier, type of the "piedmont" class, not only because it is the largest of its kind known today but because piedmont glaciers must have been widely developed during the ice age in the western United States and Canada, and probably also in Great Britain and the Alps. Attention is called also to a type known as the "bulb" or "expanded foot" glacier, which is intermediate in nature between the ordinary Alpine glacier and the piedmont type, and which was formerly very common in European fields. Excellent colored maps and many photographs of the Lucia, Galliano, Atrevidia, and other bulb glaciers supplement the careful descriptions.

The supplying ground of these great glaciers was described by Russell as a vast snow-covered region, limitless in expanse, through which hundreds of barren angular mountain peaks project. The vast white surface, unbroken by crevasses, stretches away to the horizon, interrupted only by jagged and angular mountain peaks. Between these peaks, at low points on the ridges are "through glaciers," surviving remnants of ice caps which formerly covered large tracts on the divides. These are fed by direct snowfall, avalanches and tributary glaciers from higher slopes. Vast quantities of rock waste are swept down on to the surfaces of the glaciers by frost and gravity, especially at times of earthquake activity. The load of broken rock lies concealed by clean ice until carried forward to the lower reaches where ablation (surface melting) exposes it to view as a more or less continuous "ablation moraine," from

two to fifteen feet thick. This sheet of dirt so far retards further melting that vegetation finds opportunity to get root upon the earth-smeared surface. On stagnant portions of the Malaspina glacier willows and alders have migrated inland several miles, while forests of cottonwood and spruce, at least fifty years old, cover the periphery of the glacier.

Crescentiform terminal moraines are seen near the ends of those valley glaciers where vigorous forward movement is balanced by melting, and the advancing rock debris is thus concentrated by deposition in a narrow belt; but no such accumulation of ridges is found at the margin of bulb glaciers, where wasting progresses slowly and more uniformly over the whole surface of the bulb. "In crossing the ice surface (of the Lucia glacier) one was constantly climbing over knolls and ridges and descending into valleys, some roughly circular, others linear or crescentic, and the difference in elevation from valley bottom to ridge crest was often fully 100 feet. The elevations occurred where the drift was thick, the depressions where it was thin, and it was evident that the relative positions of these higher and lower portions of the moraine surface were constantly changing as the thickness of the drift cover changed through downsliding. During the ablation of the under ice, steep slopes are developed down which the debris slides to the depressions, leaving nearly or quite bare ice slopes, while the debris accumulates in the depressions and in time doubtless accumulates to sufficient depth to retard their further reduction. Then the depressions are gradually transformed to elevations, and the former elevations, denuded of their drift cover, are lowered to valleys. Where the drainage escapes into moulins there are conditions favoring more permanent valleys. It is this constant shifting of debris that prevents the growth of vegetation on these thinner portions of the ablation moraine, and the struggle that plants are making to find a foothold here is often illustrated near the margin of the plant-covered portion of the ablation moraine, where annual plants and one or two-year-old alder and willow bushes are found overturned or dying where they stand by the removal of soil from around their roots. A second noteworthy feature of the ablation moraine was the fact that the rock fragments were all angular, so far as we were able to observe. They were frost riven fragments and avalanche falls derived from the steepened upper valley walls and in part, doubtless, supplied with the snow itself as it slid down into the reservoirs. In the outer part of the piedmont bulb the ablation moraine consisted of a confused maze of hillocks and depressions, with no definite system, and with a topography reminding one of some areas of sand dunes where ridges are absent; but farther up the glacier, where the moraine was thinner, the ablation moraine presented a series of crescentic ridges, where longtitudal ridges, perhaps medial moraines, swung across the glacier instead of down it. The cause for this peculiar arrangement of the morainic ridges is not clear, but is evidently in some way connected with the flowage of ice under the conditions of expansion into a piedmont bulb of semi-stagnant or stagnant condition."

More extensive than the moraine deposits are the outwash fans and plains, built by overloaded streams issuing from the glaciers. The topography of these great apron-like plains is complex, inasmuch as they represent alluviation for long periods of time, in which the glaciers have retreated long distances with occasional slight readvances. Instances of the destruction of earlier fan deposits by stream dissection are innumerable, and the burial of forests in many places by rapid aggradation teaches caution in the interpretation of fossil forest beds in our North American drift as records of interglacial epochs. The intricately braided

pattern of overloaded glacierfed rivers is beautifully shown by photographs and original maps. Kettleholes in early stages of development are described; and an excellent photograph of a freshly formed kettle is shown, where a block of ice has melted out within five or six years. Ice-roofed tunnels occupied by esker-building streams are not uncommon; but eskers themselves are said to be generally concealed by the extensive proglacial fans which accumulated around them as the ice front receded. Eskers are believed to be subglacial and usually if not invariably associated with conditions of stagnation. Marginal streams draining lateral hollows between wasting valley glaciers and bare rocky hillsides are forming kames and kame terraces similar to those in the northern states. Small lakes enclosed on three sides by ice and on the other by a nunatak or ice-girdled hill lend further variety to the deposits now accumulating. Thus one gets a realistic picture of conditions which existed at the border of the great North American ice sheet at the time when our country emerged from beneath it.

The question of the advance and retreat of glaciers near Yakutat Bay is given generous space, and occupies perhaps the most interesting pages of the book. The greatest extension of these glaciers is shown to have been at least several centuries ago. At that time the valleys were filled much more deeply than now, by ice which projected far out through the fjords in the form of tidal glaciers. The valleys exhibit signs of glacial abrasion and drift deposits to a considerable height above the present ice surfaces, and many tributary valleys are of the "hanging" type familiar to students of glacial geology; outwash gravels occur far beyond the reach of modern glaciers, and submerged terminal moraines can be traced across the mouths of the fjords and broad bays which these glaciers formerly filled. Following this time of great glaciation there was a recession of glaciers to points farther inland than now, allowing the forests to migrate up valleys which are today occupied by ice. The readvance thus registered by buried forest beds, however, was short-lived; for gravel deposits were overridden rather than obliterated, and sediments recording no great duration of time were deposited on the floor of a temporary lake. The recession which followed was rapid, judging from the presence in many places of a zone of morainic ground unclothed by vegetation at the ice margin, and from the comparison of photographs and maps of recent investigators with those of their predecessors. Finally, there was a sudden advance of the Yakutat Bay glaciers in 1906, which Tarr describes as follows: "Glaciers whose margins had hitherto been gently sloping moraine-covered ice banks, were transformed to steep ice cliffs, crowned by bristling ice pinnacles. Their margins were pushed forward and the heretofore stagnant piedmont bulbs were thickened. It was evident from these facts that the glaciers in question had been subjected to some sudden impulse that had caused a sudden forward movement by which they had been pushed forward, thickened, and their surfaces greatly broken. In seeking for an explanation for such a phenomenon, not hitherto recorded, only one cause seemed adequate, namely, the effect of the severe earthquake shocks to which this region was subjected in 1899." Three tests were applied to this hypothesis: (1) outside the region where the shocks had been intense no evidence of such advance was reported; (2) the advance was seen first in the smaller glaciers, coming a few years later in the larger ones; and (3) a cessation of the advance set in within a few years, coming first in the smaller glaciers. "It is believed that the observations of 1909 add the further facts necessary to demonstrate the hypothesis put forward in 1906, and that we are now warranted in stating the explanation with con-

fidence, as an established hypothesis—a new cause for g'acier advance. The sudden forward rush of a glacier, accompanied by pronounced thickening and surface breaking, may be called a glacier flood; and the resemblance to a river flood is noteworthy. When heavy rainfall or unusual melting of snow occurs in the upper reaches of a river, a wave of rising, rapidly down-moving water is started which may cause a flood all along the course, and if a portion of the river is ice covered, the ice crust will be shattered and heaved into a maze of broken ice blocks; but under ordinary conditions the river behaves more normally, slowly rising and falling with variations in supply. So in a glacier, under ordinary conditions, variations in supply manifest themselves in moderate advance or recession; but when a deluge of snow and ice is thrown down in its upper reaches the condition for a spectacular advance, a *glacier flood,* are introduced. The ice stream flows on more rapidly, its rigid upper and marginal portions are cracked and broken, its surface rises, and its front is pushed forward. There is, however, a striking difference in time occupied by the two classes of floods. A river flood passes from the source to the mouth of a river in a few hours or a few days, and its effects are soon passed; but the far less mobile ice requires several years for the transmission of the glacier flood, and its duration is months long, while years are required to bring the ice surface back to its pre-flood state. There is a striking difference, also, in the mode of motion, for the mobi'e water itself travels down stream to form the flood while in a glacier flood the advance and breaking of the mass is due to the passage of a wave, not to actual transfer of ice from glacier reservoir to terminus." The violent character of this rejuvenation of glaciers in Yakutat Bay is well shown by photographs of thoroughly crevassed glacier margins strewn with overturned forest trees and ablation moraine, and by a sketch map showing the extent of crevassing on the Malaspina glacier.

The last half of the book, written by Professor Martin, deals in similar thorough fashion with the g'aciers of the two more northerly districts. An interesting description of the Valdez glacier pictures the ice surface at its margin as disintegrated into granular particles an inch or two square, and crowned by dirt-covered cones, six or eight feet in height—gigantic anthills due to ablation. From a fragmentary frontal moraine a broad, well formed outwash plain, descending 60 feet to the mile, reaches three and a half miles down the fjord. This plain is much scarred by dry channels, and near the ice front is pitted with newly formed kettles. Vegetation cannot get a foothold on its flood-swept surface. The Columbia g'acier receives attention as the largest one of the region, with a width of four mi'es and a probable length of twenty-five. Although tidal in the sense that it terminates in the sea "in a beautiful pinnacled and crevassed snowy-white sinuous precipice of ice," from 100 to 250 feet in height, it is grounded firmly on the floor of the fjord, which at only one point exceeds 800 feet depth. This is valuable as a reminder that glaciers are capable of excavating rocky fjords to a depth considerably below sea level, and retreating to leave "drowned valleys" even when no relative change of level of land and sea takes place. Unlike most Alaskan glaciers, the Columbia has been in fairly constant advance during the quarter century of observation. In 1909-10 it was advancing at the rate of two feet a day, plowing up a "push moraine" of dirt and overturned forest. Shell-bearing clays from the sea floor were pushed up to a height of twenty feet on this moraine. The question whether the advance is due to recent earthquakes, as in the case at Yakutat Bay, or to temporary local increase in snowfall, is discussed but left unsettled. The recent spectacular advance of the Childs glacier into dan-

Essentials of Agriculture

By Henry Jackson Waters, President of Kansas State College of Agriculture

This is the best usable textbook on agriculture published for high schools. Everyone interested in securing vital results from the teaching of agriculture will be interested in this book. Nothing has been spared in text, illustrations, exercises and mechanical aids to add the merit of beautiful bookmaking to its scientific and educational merits. It represents the culmination of the new scientific thought applied to the best farm practice, and should go far toward making the study of agriculture one of the regular high-school science courses. $1.25.

GINN and COMPANY, *Publishers*

Boston **New York** **Chicago** **London**
Atlanta **Dallas** **Columbus** **San Francisco**

gerous proximity to the million dollar bridge of the Copper River railroad is described by Professor Martin in animated but accurate language. The rescue of the bridge by the river itself, which, swollen by rains at the critical time, attacked the margin of the glacier with such vigor as to offset the forward movement of ice, leads the author to take a rather optimistic view regarding other advances of this kind in the future.

Although suffering by comparison with the fine colored maps already mentioned, several charts of Alaskan fjords, in the text of the book, in black and white, deserve attention on account of the submerged contours, which bring out plainly the presence of moraine-bars and rock reefs due to glacial action. Hanging side valleys drowned by the sea are also shown. The illustrations elsewhere in the book are so admirable that one hesitates to complain of a few poorly prepared figures (Figs. 26, 58, 28, 69, and 70), copies of maps by the Geological Survey and the Coast and Geodetic Survey, in muddy half-tones instead of clean-cut black and white line drawings.

One leaves the book convinced that there is no field in the country so rich in material for geographic research and exploration as Alaska. The National Geographic Society is to be congratulated on the production of so valuable a monograph. J. W. G.

The Merriam-Websters Dictionaries have just received the Grand Prize (highest award) at the Panama-Pacific Exposition.

Plane Geometry, by Webster Wells and Walter W. Hart, Assistant Professor of Mathematics in the University of Wisconsin Course for the Training of Teachers. Pages viii+309. 12.5x18 cm. 1915. D. C. Heath & Co., New York.

This interesting revision of Wells' *Essentials of Geometry* is announced to be in accord with current scientific and pedagogical thought. Some of the features which may commend it to the attention of teachers who are intending to make a change in textbook are the following: In each book the theorems of fundamental importance are given first, then come other theorems and material which may be omitted; in the beginning only the concepts, notation and terminology needed at once are given; constructions are placed early, as soon as they can be proved; unnecessary corollaries are omitted.

Exercises follow most of the propositions; incommensurable cases are postponed till the theory of limits is given near the close of the book; modern and consistent definitions are given (it is refreshing to have a good definition of a limit in an elementary geometry); details of demonstrations which pupils can easily supply are increasingly omitted; pupils are encouraged to plan their proofs before attempting blindly to give a demonstration. This book has so many good qualities that it seems a decided loss that the author loses sight of the fact that geometry may have some close connections with algebra, arithmetic and other matters of interest to pupils.

H. E. C.

Grundlehren der Mathematik für Studierende und Lehrer, I. Teil, II. Band, Algebra, by Dr. Eugen Netto, Professor in the University of Giessen. Pages xii+232. 16×23.5 cm. M. 7. 20. 1915. B. G. Teubner, Leipsic.

A systematic treatment of the fundamental principles of the topics under consideration is here given for the purpose of preparing students for well-grounded advance in algebra. The titles of the chapters are: "Determinants"; "Functions"; "Elementary Properties of Integral Functions of One Variable"; "Equations"; "Linear Equations"; "Resultants and Discriminants"; "Equations of the Second, Third and Fourth Degrees"; "Proof of the Existence of Roots; Single and Double-Valued Functions"; "Roots of Unity"; "Die Kreisteilungsgleichungen"; "Cyclic and Reciprocal Equations"; "Substitution Groups"; "The Solution of Algebraic Equations"; "Transformation, Invariants and Covariants"; "Sturm's Theorem."

H. E. C.

Principles of Cooking, by Emma Conley. 205 pages. American Book Co., Chicago.

This is a clear, concise little manual, containing many good recipes so grouped and treated as to bring out their relations to each other as variations of a few standard combinations of good materials. This practice in cooking is interspersed with suggestions for table service, for menu making; tables showing the chemical composition of good materials are added, also very excellent suggestions for the teacher, treating equipment, the question of serving school lunches, lists of bulletins for reference work, etc.

M. C. D.

Household Accounting, by Whigam and Frederick. 47 pages. A. N. Palmer Co.

This is a set of exercises showing convenient and systematic methods of keeping account of outgoing and incoming cash, for the boy or girl at school, for a small business concern, for the housewife in charge of family expenses. Useful suggestions are made for various problems of household management, for determining budget, for drawing checks, for making monthly and yearly statements, for keeping petty expense and cash books; a set of blank forms, illustrating various details and methods, is supplied with the book, which will be of great interest to teachers of household management.

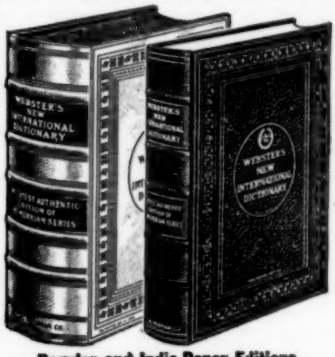
M. C. D.

"Training Children *to a competent and ready use of the Dictionary and fixing the habit of consulting it, is one of the main duties that the school can perform for the student," says DR. SUZZALLO, President, University of Washington, Seattle.*

Are your pupils forming the Dictionary Habit? Is your school equipped with the Latest and Best Dictionary—

WEBSTER'S NEW INTERNATIONAL?

This *New* Creation is an all-knowing special teacher answering with *final* authority all kinds of puzzling questions in spelling, pronunciation, definition, history, geography, biography, sports, arts, and sciences.



400,000 Vocabulary Terms. **New Gazetteer.**
12,000 Biographical Entries. **2700 Pages.**
Over 6000 Illustrations. **Colored Plates.**

The One Supreme Authority. It is the ***standard*** of the Federal and State Courts. The ***standard*** of the Government Printing Office. The ***standard*** of nearly all the schoolbooks. ***Indorsed*** by State School Superintendents. ***All States*** (30 in number) that take official action regarding the adoption of dictionaries recognize the Merriam Series as authoritative.

Would not a request to your school authorities bring the NEW INTERNATIONAL to your schoolroom? Give your pupils every opportunity to fix the dictionary habit.

Write for specimen pages, FREE.

Regular and India-Paper Editions.

G. & C. MERRIAM CO., SPRINGFIELD, MASS.

GRAND PRIZE (Highest Award) Panama-Pacific Exposition.

The Merriam-Websters Dictionaries have just received the GRAND PRIZE (highest award) at the Panama-Pacific Exposition

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become a year old.

American Association for the Advancement of Science.

President, W. W. Campbell, University of California; *Vice-Presidents,* Section A: A. O. Leuschner, University of California; Section B: Frederick Slate, University of California; Section C: W. McPherson, Ohio State University; Section D: Bion J. Arnold, Chicago; Section E: C. S. Prosser, Ohio State University; Section F: V. L. Kellogg, Stanford University; Section G: W. A. Setchell, University of California; Section H: G. M. Stratton, University of California; Section I: Geo. F. Kunz, New York; Section K: F. P. Gay, University of California; Section L: E. P. Cubberley, Stanford University; Section M: Eugene Davenport, University of Illinois; *Permanent Secretary,* L. O. Howard, Smithsonian Institution, Washington; *General Secretary,* Henry Skinner, Academy of Natural Sciences, Philadelphia, Pa.; *Secretary of the Council,* Prof. W. E. Henderson, Ohio State University; *Association Secretary for the South,* Robert M. Ogden, University of Kansas, Lawrence, Kan.; *Secretary of Pacific Division,* Albert L. Barrows, University of California Library, Berkeley, Cal.; *Secretaries of the Sections:* A.—Mathematics and Astronomy, Forest R. Moulton, University of Chicago, Chicago, Ill.; B.—Physics, William J. Humphreys, U. S. Weather Bureau, Washington, D. C.; C.—Chemistry, John Johnston, Geophysical Laboratory, Carnegie Institution of Washington, Washington, D. C.; D.—Engineering, Arthur H. Blanchard, Columbia University, New York, N. Y.; E.—Geology and Geography, George F. Kay, State University of Iowa, Iowa City, Iowa; F.—Zoölogy, Herbert V. Neal, Tufts College, Mass.; G.—Botany, W. J. V. Osterhout, Harvard University, Cambridge, Mass.; H.—Anthropology and Psychology, George G. Mac-

Curdy, Yale University, New Haven, Conn.; I.—Social and Economic Science, Seymour C. Loomis, 69 Church Street, New Haven, Conn.; K.—Physiology and Experimental Medicine, C. E. A. Winslow, State Board of Health, New York, N. Y.; L.—Education, Stuart A. Courtis, Liggett School, Detroit, Mich.; M.—Agriculture, Edwin W. Allen, Office of Experiment Stations, U. S. Department of Agriculture, Washington, D. C.; *Treasurer*, R. S. Woodward, Carnegie Institution of Washington, Washington, D. C.; *Assistant Secretary*, F. S. Hazard, Office of the A. A. A. S., Smithsonian Institution, Washington, D. C.—115.

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

President, Glenn W. Herrick, Ithaca, N. Y.; *First Vice-President*, R. A. Cooley, Bozeman, Mont.; *Second Vice-President*, W. E. Rumsey, Morgantown, W. Va.; *Third Vice-President*, E. F. Phillips, Washington, D. C.; *Secretary*, A. F. Burgess, Melrose Highlands, Mass.—115.

AMERICAN MATHEMATICAL SOCIETY.

President, Prof. E. W. Brown, Yale; *Vice-Presidents*, Prof. F. R. Moulton, Chicago, and Prof. Oswald Veblen, Princeton; *Secretary*, Prof. F. N. Cole, Columbia; *Treasurer*, Prof. J. H. Tanner, Cornell; *Librarian*, Prof. D. E. Smith, Columbia.—115.

AMERICAN MICROSCOPICAL SOCIETY.

President, Prof. C. A. Kofoid, University of California, Berkeley, Cal.; *First Vice-President*, Prof. L. D. Swingle, University of Utah, Salt Lake City, Utah; *Second Vice-President*, Dr. N. A. Cobb, U. S. Dept. of Agriculture, Washington, D. C.; *Secretary*, T. W. Galloway, Millikin University, Decatur, Ill.; *Treasurer*, T. L. Hankinson, Eastern Illinois State Normal, Charleston, Ill.—115.

AMERICAN PALEONTOLOGICAL SOCIETY.

President, E. O. Ulrich, Washington, D. C.; *Vice-Presidents*, J. C. Merriam, Berkeley, Cal.; Gilbert Van Ingen, Princeton, N. J.; F. H. Knowlton, Washington, D. C.; *Treasurer*, R. S. Lull, New Haven, Conn.; *Secretary*, R. S. Bassler, Washington, D. C.

AMERICAN PHYSICAL SOCIETY.

President, Ernest Merritt; *Vice-President*, K. E. Guthe; *Secretary*, A. D. Cole; *Treasurer*, J. S. Ames; *Members of Council*, C. E. Mendenhall and G. W. Stewart; *Editorial Board*, J. S. Ames, A. A. Michelson and E. Buckingham.—115.

AMERICAN SOCIETY OF NATURALISTS.

President, Frank R. Lillie, University of Chicago; *Vice President*, Rollin A. Emerson, Cornell University; *Secretary*, Bradley M. Davis, University of Pennsylvania; *Treasurer*, J. Arthur Harris, Carnegie Station for Experimental Evolution.—115.

ASSOCIATION OF AMERICAN GEOGRAPHERS.

President, Richard Elwood Dodge; *Vice-Presidents*, Mark Jefferson and Frank Carney; *Secretary*, Isaiah Bowman, Yale University, New Haven, Conn.; *Treasurer*, F. E. Matthes, U. S. Geological Survey, Washington, D. C.; *Editor*, Harlan H. Barrows, University of Chicago, Chicago, Ill.—115.

ASSOCIATION OF MATHEMATICAL TEACHERS IN NEW ENGLAND.

President, Prof. Julian L. Coolidge, Harvard University; *Vice-President*, Prof. F. C. Ferry, Williams College; *Treasurer*, Mr. F. W. Gentleman, Mechanic Arts H. S., Boston; *Secretary*, Mr. H. D. Gaylord, 104 Hemenway St., Boston; *Members of the Council*, Miss Clara A. Snell, H. S., Melrose, Mass., Mr. Wm. L. Bosburgh, Normal School, Boston, Prof. Eva M. Chandler, Wellesley College, Mr. Harry B. Marsh, Technical H. S., Springfield, Mass., Miss Harriet R. Pierce, High School, Worcester, Mass., Mr. Elmer Case, High School, Brookline, Mass.—115.

ASSOCIATION OF OHIO TEACHERS OF MATHEMATICS AND SCIENCE.

President, C. C. Morris, Ohio State University, Columbus; *Vice-President*, S. J. Mauchly, Woodward High School, Cincinnati; *Secretary-Treasurer*, E. W. E. Schear, Otterbein University, Westerville.

ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

President, Eugene Randolph Smith, The Park School, Baltimore, Md.; *Vice-President*, Paul Saurel, College City of New York; *Treasurer*, Edward D. Fitch, The Delancey School, Philadelphia, Pa.; *Secretary*, F. Eugene Seymour, State Normal School, Trenton, N. J.

An Announcement Of Great Importance

Weston

Model 310, Single Phase and Direct Current

PORTABLE ELECTRODYNAMOMETER WATTMETER

A Wattmeter that will indicate with equal accuracy (guaranteed ¼ of 1 per cent) on either A. C. or D. C. Circuits. They can be used on circuits of any commercial frequency without appreciable error.

They are provided with double ranges. Overload capacity 100 per cent without introducting error.

They have an extremely low moment of inertia; effectively damped; independent of room temperature and are shielded from external magnetic fields.

The scales, which are 5½ inches long, are **uniform** throughout their **entire** length, a characteristic of great importance. Each scale is hand calibrated and provided with a mirror over which the knife-edge pointer travels and pointers are equipped with a simple zero setting device.

For complete information regarding Model 310 Wattmeters and Model 329 Polyphase Wattmeters write for Bulletin No. 2002.

Have you the Weston Monograph B-5 issued for Science Teachers?

WESTON ELECTRICAL INSTRUMENT CO., 45 Weston Ave., Newark, N. J.

New York, Philadelphia, Buffalo, Petrograd, Chicago, Boston, Detroit, St. Louis, Cleveland, Denver, Johannesburg, Cincinnati, San Francisco, Richmond, South Africa, Winnipeg, Toronto, Montreal, Vancouver, Paris, Berlin, London

For Your Laboratory

GUERNSEYWARE

Made in Cambridge Ohio U. S. A.

Casseroles
Evaporating Dishes
Crucibles

Mortars with Pestles
Petri Dishes
Complete Line

Guaranteed the equal of any Porcelain Ware made in the World

Tested and Found True

Catalogue now ready. Mailed on request, with complete Price List.
Write us for prices and data before you place your next order.

The Guernsey Earthenware Company

21 East End Street **Cambridge, Ohio, U. S. A.**

BOTANICAL SOCIETY OF AMERICA.

President, John M. Coulter; *Vice-President,* R. A. Harper; *Treasurer,* Arthur Hollick; *Councilor,* U. F. Ganong.—115.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

President, C. E. Spicer, Township High School, Joliet, Ill.; *Secretary,* A. W. Cavanaugh, Lewis Institute, Chicago, Ill.; *Treasurer,* H. R. Smith, Lake View High School, Chicago, Ill.; *Vice-President,* Jessie F. Caplin, West High School, Minneapolis, Minn.; *Assistant Secretary,* M. Faith McAuley, High School, St. Charles, Ill.; *Assistant Treasurer,* H. H. Radcliffe, High School, Connersville, Ind. Agriculture—*Chairman,* A. W. Nolan, University of Illinois, Urbana, Ill.; *Secretary,* Lester S. Ivins, Supervisor of Agricultural Education, Lebanon, O.; Biology—*Chairman,* Fred T. Ullrich, Normal School, Plattesville, Wis.; *Secretary,* Nettie M. Cook, High School, Springfield, Ill.; Chemistry—*Chairman,* L. B. Altaffer, West High School, Cleveland, Ohio; *Secretary,* Emma J. Fordyce, High School, Cedar Rapids, Iowa; Earth Science—*Chairman,* C. S. Winslow, Senn High School, Chicago, Ill.; *Secretary,* Miss A. E. Aitchison, State Teachers College, Cedar Falls, Iowa; Home Economics—*Chairman,* Agnes K. Hanna, University of Chicago; *Secretary,* Minna C. Denton, Ohio State University, Columbus, O.; Mathematics—*Chairman,* Edith Long, Lincoln High School, Lincoln, Neb.; *Secretary,* Marie Gugle, Supervisor of High Schools, Columbus, O.; Physics—*Chairman,* T. L. Harley, Hyde Park High School, Chicago, Ill.; *Secretary,* Isabel B. Johnson, Milwaukee-Downer Seminary, Milwaukee, Wis.; *Annual meeting,* November 26 and 27, 1915, Chicago.—1214.

CHEMISTS CLUB OF NEW YORK.

President, Prof. M. C. Whitaker, Columbia University; *Resident Vice-President,* Dr. B. C. Hesse, 90 William St.; *Treasurer,* Albert Plaut, 120 William St.; *Secretary,* Prof. Reston Stevenson, College City of N. Y.—115.

CHEMISTRY TEACHERS' CLUB OF NEW YORK CITY.

President, Augustus Klock, Ethical Culture High School, Manhattan; *Vice-President,* Chas. H. Vosburgh, Jamaica High School, Jamaica, L. I.; *Secretary,* Oscar R. Flynn, High School of Commerce, Manhattan; *Treasurer,* W. L. Estabrooke, The College of the City of New York.—115.

COLORADO MATHEMATICS ASSOCIATION.

President, Ira M. DeLong, University of Colorado, Boulder, Colo.; *Secretary-Treasurer,* Grace Ellen Shoe, North Side High School, Denver, Colo.—115.

ILLINOIS STATE ACADEMY OF SCIENCE.

President, U. S. Grant, Northwestern University, Evanston; *Vice-President,* E. W. Washburn, University of Illinois, Urbana; *Secretary,* A. R. Crook, State Museum, Springfield; *Tresaurer,* H. S. Pepoon, Lake View High School, Chicago; *Publication Committee,* The President, the Secretary and C. H. Smith, Editor SCHOOL SCIENCE AND MATHEMATICS, 5517 Cornell Ave., Chicago.

INDIANA ACADEMY OF SCIENCE.

President, Wilbur A. Cogshall, 423 S. Fess Ave., Bloomington, Ind.; *Vice-President,* William A. McBeth, State Normal, Terre Haute; *Secretary,* Andrew J. Bigney, Moores Hill; *Treasurer,* William M. Blanchard, Greencastle; *Editor,* Harry E. Barnard, State House, Indianapolis; *Press Secretary,* Frank B. Wade, Shortridge High School, Indianapolis.—115.

IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

President, W. E. Beck, Iowa City High School, Iowa State University; *Vice-President,* Maud St. John, East Des Moines High School; *Secretary-Treasurer,* Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa.

IOWA ASSOCIATION OF SCIENCE TEACHERS.

President, Emma J. Fordyce, High School, Cedar Rapids, Ia.; *Vice-President,* A. G. Heitman, High School, Sioux City, Ia.; *Secretary-Treasurer,* J. A. Burrows, West High School, Des Moines, Ia.; Section Leaders: Physics, Prof. L. B. Spinney, Iowa State College, Ames, Iowa; Chemistry, Prof. C. O. Bates, Coe College, Cedar Rapids, Ia.; Physiography, Etta M. Bardwell, High School, Cedar Rapids, Ia.; Biology, Prof. E. L. Palmer, Cedar Falls, Iowa.—115.

KANSAS ASSOCIATION OF MATHEMATICS TEACHERS.

President, Lucy T. Dougherty, High School, Kansas City, Kan.; *Vice-President,* Supt. H. C. McMillan, Kingman; *Secretary-Treasurer,* Eleanor Harris, Hutchinson High School.—115.

Bank's Generator for H_2S, Etc.

Advantages:

1. Portable.
2. Absence of odor, allowing apparatus to be kept on the desk.
3. Precipitation under constant pressure, which can be regulated at will.
4. Definite means of ascertaining when precipitation is completed.
5. Elimination of loss due to bubbling.

THIS apparatus is somewhat of a new departure and presents a most satisfactory solution of the H_2S problem. Precipitations are made in a closed flask, the H_2S being confined under pressure above the solution to be saturated. This allows more rapid absorption of the gas in proportion to the pressure, according to Henry's Law, and of course eliminates the nuisance and odor of H_2S in the laboratory.

The generator automatically maintains any desired pressure in the precipitating flask up to nearly 2 atmospheres, the gas being evolved only as fast as it is absorbed by the solution. This last feature means absolute economy and makes it possible for a very small generator to do the work of a much larger one of the old type.

It is unnecessary to use the apparatus under a hood since no gas escapes into the laboratory, and on account of its compact form it may be kept on the desk with other reagent bottles.

PRICE LIST.

Bank's Generator, complete as illustrated	net	$2.50

SPARE PARTS.

Manometer tube	each, net	.10
Iron Sulphide container with disc	each, net	.30
Hard rubber pinchcock	each, net	.25

Special Prices will be quoted on application for orders of over One Dozen Generators at a time

EIMER AND AMEND

FOUNDED 1851

HEADQUARTERS FOR LABORATORY SUPPLIES

NEW YORK, N. Y.
205 Third Ave.

PITTSBURGH, PA.
3006 Jenkins-Arcade

MATHEMATICAL AND PHYSICAL SECTION OF THE ONTARIO EDUCATIONAL ASSOCIATION.

Hon. President, T. A. Kirkconnell, M. A., Lindsay Coll. Inst.; *President,* A. M. Overholt, M. A., Sarnia Coll. Inst.; *Vice-President,* R. Wightman, B. A., Harbord Coll. Inst., Toronto; *Secy.-Treas.,* W. J. Longheed, M. A., Jarvis Coll. Inst., Toronto.—114.

MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS AND SCIENCE.

President, Clyde Hill, Springfield; *Secretary,* L. D. Ames, Columbia; *Treasurer,* A. J. Schwartz, McKinley High School, St. Louis; Mathematics Division—*Vice President,* R. E. White, Kirksville; *Secretary,* Elizabeth Rutherford, St. Joseph; Science Division—*Vice President,* A. C. Magill, Cape Girardeau; *Secretary,* E. B. Street, Mexico.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

President, Wilhelm Segerblom, Phillips Exeter Academy, Exeter, N. H.; *Vice-President,* N. Henry Black, Roxbury Latin School, Roxbury, Mass.; *Curator,* Lyman C. Newell, Boston University, Boston, Mass; *Secretary,* John B. Merrill, East Boston High School; *Treasurer,* Alfred M. Butler, High School of Practical Arts.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

President, Bryan O. Burgin, Albany High School, Albany, N. Y.; *Vice-President,* Ernest F. Conway, Central High School, Syracuse, N. Y.; *Secretary-Treasurer,* Harry A. Carpenter, West High School, Rochester, N. Y.—115.

PHYSICS CLUB OF NEW YORK CITY.

President, Ben M. Jaquish, Erasmus Hall High School, Brooklyn; *Vice-President,* William F. Evans, Girls' High School, Brooklyn; *Secretary,* Augustus Klock, Ethical Culture High School, New York; *Treasurer,* Charles J. Young, Montclair High School, Montclair, N. J.—115.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

President, Anson Marston, Iowa State College, Ames, Iowa; *Vice-Presidents,* Henry H. Norris, Electric Railway Journal, New York and C. Russ Richards, University of Illinois, Urbana, Ill.; *Secretary,* F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.; *Treasurer,* W. O. Wiley, 432 Fourth Avenue, New York City.—115.

SOCIETY FOR PRACTICAL ASTRONOMY.

President, Treasurer *pro tempore,* Frederick C. Leonard, 1338 Madison Park, Chicago, Ill.; *Secretary,* John E. Mellish, R. F. D., Cottage Grove, Wis.; *Council,* the President (Chairman), the Secretary, and Horace C. Levinson, Chicago, Ill.; *Directors of the Observing Sections,* Planetary and Lunar—Latimer J. Wilson, Nashville, Tenn.; Solar—Richard H. Swift, Chicago, Ill.; Spectroscopic—S. F. Maxwell, Dearborn Observatory, Northwestern University, Evanston, Ill.; Photographic—Horace C. Levinson, Chicago, Ill.; Meteor—Charles P. Oliver, Ph. D., Leander McCormick Observatory, the University of Virginia; Comet—William H. Steavenson, London, England; Auroræ, Zodiacal Light and Gegenschein—Alan P. C. Craig, Corona, Cal.; Nova Search—Nels Bruseth, Arlington, Wash.; Section for Construction of Astronomical Instruments—M. Thomas Fullan, B. S., M. E., Alabama Polytechnic Institute, Auburn, Ala.; (unofficial) Section for the Practical Teaching of Astronomy—Mary E. Byrd, Ph. D., Lawrence, Kans.; *Editors,* Frederick C. Leonard and Horace C. Levinson, Chicago, Ill.; *Librarian*—S. F. Maxwell, Evanston, Ill.

SOCIETY OF AMERICAN BACTERIOLOGISTS.

President, D. H. Bergey, University of Pennsylvania, Philadelphia, Pa.; *Vice-President,* John Weinzirl, Seattle, Washington; *Secretary-Treasurer,* A. Parker Hitchens, Glenolden, Pa.—115.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.

President, Mabel B. Peirson, High School, Pasadena; *Vice-President* E. E. Allen, Occidental College, Los Angeles; *Secretary-Treasurer,* C. M. Westcott, High School, Hollywood; *Mathematics Section Chairman,* W. A. Newlin, High School, Pasadena; *Biology Section Chairman,* L. H. Miller, State Normal School, Los Angeles; *Earth Science Section Chairman,* Grace M. R. Abbot, High School, Venice; *Physics-Chemistry Section Chairman,* J. H. Norton, High School, Gardena.